

EDITED BY
JERRY POURNELLE AND JIM BAEN

FAR

SOON TO BECOME NEW DESTINIES

FRONTIERS



**BAEN
BOOKS**

65606-6 • \$2.95

THE PAPERBACK MAGAZINE OF
SCIENCE FICTION AND SPECULATIVE FACT

VOLUME VII/WINTER 1986

FRONTIERS

EDITED BY
**JERRY POURNELLE
AND JIM BAEN**

0-677-65606-6

EDITED BY

JERRY POURNELLE AND JIM BAEN

FAR

SOON TO BECOME *NEW DESTINIES*

FRONTIERS

Fall Edition 1986

EDITORS IN CHIEF

Jerry Pournelle Jim Baen

SENIOR EDITOR

Elizabeth Mitchell

ASSOCIATE EDITOR

Michael Banks



FAR FRONTIERS, Volume VII

This is a work of fiction. All the characters and events portrayed in this book are fictional, and any resemblance to real people or incidents is purely coincidental.

Copyright © 1986 by Baen Publishing Enterprises

All rights reserved, including the right to reproduce this book or portions thereof in any form.

A Baen Books Original

Baen Publishing Enterprises
260 Fifth Avenue
New York, N.Y. 10001

First printing, December 1986

ISBN: 0-671-65606-6

Cover art by A. C. Farley

Printed in the United States of America

Distributed by
SIMON & SCHUSTER
TRADE PUBLISHING GROUP
1230 Avenue of the Americas
New York, N.Y. 10020

CONTENTS

ON TIMELINE SINGULARITIES, SPACE, AND HUMAN HISTORY, Charles Sheffield	1
IRON, Poul Anderson	20
LORD RIFKIN'S RISK, Ralph Roberts	97
TEDDY BUG AND THE HOT PURPLE SNOWBALL, Phillip C. Jennings	130
GUARDIAN ANGEL, Timothy Zahn	150
TIMEWARPS REVISITED, John Gribbin	172
THE ARMISTICE, Robert Reed	184
LEADING EDGE, Roland Green	193
AMERICA: A SECOND-CLASS SPACE POWER, G. Harry Stine	202
WINGED MYSTERIES— THE SOVIET SHUTTLES, Roger MacBride Allen	230
YOUNG AS YOU FEEL, Roger MacBride Allen	251

ON TIMELINE SINGULARITIES, SPACE, AND HUMAN HISTORY

When was the last time you read a believable story that purported to take place more than, say, fifty or a hundred years from now? Not post-holocaust or post-techno-collapse futures, but stories that take place in a future that has experienced no break in the smooth progression of scientific and technological progress.

Although that was not its primary focus, this article explains why it has become so very difficult to write plausible science fiction that takes place more than a few decades hence: beyond that point the basic nature of a catastrophe-free future is quite literally unimaginable. Here's why . . .

—JPB

ON TIMELINE SINGULARITIES, SPACE, AND HUMAN HISTORY

Charles Sheffield

Cycles and history

The story begins with Oswald Spengler and Arnold Toynbee. Toynbee was a professional historian and linguist, Spengler a philosopher who wrote about history. Between them, in the first two decades of this century, they proposed and popularized the idea that the best way to characterize human history is not through the actions of generals, kings, and emperors, or through the progress and course of single nations. Instead, history should be viewed in terms of the large, multi-generation cycles through which a civilization will pass as it rises, reaches maturity, and finally declines.

The end may be slow, like the dissolution of the Roman Empire; the beginning may also be slow, like the British conquest of India. Or the process may be rapid, like the fall of Troy, the destruction of the Aztec civilization by Cortes and the Spanish *conquistadores*,

or the fragmentation of Alexander the Great's empire after his early death. But given certain facts about the growth of a civilization, deductions can then be made about its most likely future course.

It's a nice, neat theory. It allows analogies and interesting analysis. But I think it is wrong in important ways. In my opinion human history is better defined by a succession of major, one-way changes; what I like to think of as *singularities* of the historical timeline. These singularities are inventions or developments that totally changed human existence after them.

There are of course changes going on all the time. But we can distinguish long, smooth periods of minor change, and periods of violent and major change. The major changes are apt to be social catastrophes from the point of view of the people living through them. Many would say it is nicer to live during the long, smooth periods. Remember the Chinese curse, "May you live in *interesting* times"—i.e. may you live in a period when your society collapses, everything changes, and people no longer know what is happening. A major change may take a long time to have its effect; more than one generation. In a way, that makes things even more confusing to the participants.

The first singularity

Let's look at some examples of major discontinuities, things that changed our world. The first one, and probably the most important of all, was the discovery of the use of fire.

It happened long ago, in early paleolithic times, so long ago that we have no idea how it happened. We don't know if it was the work of some single stone-age supergenius, how many false starts were made, what disasters were encountered along the way, or who the heroes and heroines of the time were. We can, however, clearly see some of the effects, the things that fire

gave us in addition to french fries, hamburgers, Irish coffee, Julia Child, and other phenomena of our times.

The first thing that fire offered the species was a concentrated source of energy. I sometimes like to think of human progress as defined by the available energy densities. From that point of view fire was the dominant influence on human history from the early stone age until almost one century ago. Fire derives its energy from chemical processes, and they in turn depend on the property of the outer electron shells of atoms. In 1896 the discovery of radioactivity by Henri Becquerel introduced the next higher level of energy densities: those derived from the nucleus of the atom rather than its surrounding electrons.

Thanks to fire, humans were no longer totally dependent on "diffuse" energy sources—winds, streams, sunlight, and draft animals. Fire offered an order of magnitude greater density of available energy, just as nuclear power in its turn increased the energy density by an order of about one million.

(As an added and probably unpopular thought, I believe that there is good reason why Solar Power Satellites have not been *and never will be* a competitive source of power. They propose to make use of a highly diffuse energy source, sunlight, when the direction of history has taken us constantly to more concentrated and intense energy sources. Sure, we'll put our energy producers in orbit and beam the power down, because we don't want to mess up the surface of the Earth; but the source of that power will be controlled fusion, or whatever technology lies a generation beyond that. We won't fiddle about with square kilometers of solar cells when we can produce the same amount of energy in something the size of an automobile. Fondness for Solar Power Satellites is to me a form of nostalgia, like being excited about windmills.)

Some of the other, less obvious consequences of a mastery of fire: for the first time, humans were not tied to a circadian rhythm imposed by the succession of light

and dark. We could operate independent of the limitations imposed by available sunlight or moonlight.

It's very difficult for most of us to realize, living in the cities, just how dark "dark" is. Even when we go camping, we carry flashlights and lanterns. Total darkness is very unfamiliar. We can scarcely imagine what a cloud-covered night must have been like, ten thousand years ago; maybe like spelunking without lights—and that's a scary notion. It's one of our oldest and deepest fears, to be seized in the night by something we can't see. It ought to send a shiver up most backs, no matter how civilized, because the fear is hidden away in the hindbrain where the oldest terrors reside. But with the discovery of fire—and light—those fears were lessened. Humans became masters of the twenty-four hour day.

Next, fire became the basis for technology. Almost everything we do, from extraction of raw materials to making final products, calls for the application of substantial heat. Until recently, production technology *was* fire. (I am prepared to entertain a counter-claim, which argues that our technology derived from the use of tools. Since we have no idea how those two developments were linked in history, it's not really a good subject to argue about.)

Fire did at least one other significant thing. It provided our species with the first elite, the group of "insiders" who had powers that average people held in awe. It introduced the idea of the Guardians of the Flame, the Keepers of Mystery.

That idea is still with us. It shows up in the typical paranoid attitude, the idea that there is somewhere an insider group, the "secret masters" who control everything. Fire encourages mystery. Think how baffling it must have been when the first attempts were made to understand it. Perhaps the people who conquered their own instinctive fear of fire enough to control it and use it were *truly* an elite, more so than any of the insider groups that succeeded them.

A hundred thousand years ago, fire had been seen only from a distance. And all natural instincts told hu-

mans to run away from it. Someone had to approach it, and turn it from an unknown terror to a human tool. That was a near-unbelievable achievement of the mind of some member of *homo sapiens*, overriding an instinctive animal fear with the curiosity of the true human.

It's an interesting mental exercise to try to see the world through the eyes of our ancestors at the time that the use of fire was being explored. Fire fascinates us, even today. How mysterious and awe-inspiring it must have been at the dawn of the species—something so insubstantial that it could not be grasped, but at the same time something that could do terrible damage and inflict terrible wounds. Fire was on the one hand infinitely powerful and dangerous, on the other hand infinitely fragile and easily quenched by a careless action. This paradox, the coupling of the infinitely strong and the hopelessly weak, must have led to some very strange patterns of human thought. Who was the first person to ask that his body be cremated, and why?

And when the delicate flame failed and vanished, what were the tribe's feelings of despair? There are still primitive tribes today, who when fires go out will seek neighboring tribes and borrow a flame, rather than attempting to light their own. The idea that you rub sticks, or strike pieces of flint together, and easily have a new fire, is not a plausible one; the technology for the creation of fire must have been closely guarded and sacred.

The second singularity

The second singularity of our time line is less dramatic than fire, but perhaps just as important. It is agriculture.

Agriculture brought us, along with fire, to baked potatoes, apple pie, and *crepes Suzettes*; but to get us there it first had to do something much more important. It led to the creation of *permanent settlements*. With planned agriculture, the nomadic life of the early days

of our species was not merely *unnecessary*—it was positively undesirable. Permanent settlements developed, and grew to become villages, towns and cities. It became possible for a human being to spend a whole life without moving more than a few miles from the place of birth. It's hard to imagine that, in our own peripatetic society, but it was the norm just a couple of centuries ago.

As important as the establishment of settlements is the concept of *work*. I don't think that anyone in the days of the food hunters ever realized there was such a thing as work. Gathering food was just something that one did, a natural part of existence.

But agriculture is an intensive way of producing food. To draw an analogy, if fire allowed us to move from diffuse to concentrated *energy* production, then agriculture allowed us to move from diffuse to concentrated *food* production. Food *growing* is more efficient than food *gathering*. That had a secondary result: although for some people the agricultural life became one of continuous toil and labor, there is enough spare capacity in the agricultural system, because it is an efficient way of producing food, to permit the existence of a leisure class and aristocracy. There could be people who worked, and people who did not work. Social stratification had begun; and with it, the ownership of substantial personal property.

The idea of "owning" land makes little sense unless you have a system of fields to till, though of course the "territorial imperative" practiced by many animals, including man, leads naturally to it. But it is an odd idea, that one person can own permanently a piece of the Earth. It does not sound strange to us, because we are used to it. It came in with agriculture.

The third thing that agriculture provided was the stimulus for *biological* science and technology. Fire paved the way for the "hard" technologies—metallurgy, engineering, chemistry, and physics. Agriculture initiated the "soft" technology of biology. We tend to associate natural selection completely with the name of Charles

Darwin, and think of it as part of the theory of evolution. But *unnatural* selection—selective cultivation—was practiced by farmers on crops and animals long before there were any theories of evolution. Farmers and breeders knew, thousands of years ago, what was needed to select desirable properties. One simply bred from the species' members that exhibited what you wanted. And later, one tried cross-species fertilization to introduce more variety in the outcome. Only recently did people think it important to give a name to a process that was in use long before Darwin.

Agriculture did two other things that we might easily lose sight of. It was a major stimulus for the development of astronomy, because to know the date of planting, or field flooding, it was necessary to know something of the movement of the moon, sun and planets. Agriculture was at the same time a terrific stimulus to civil engineering. The ability to build canals, pumps, sluice gates, and water-distribution systems had great practical value.

Like fire, agriculture led to irreversible, enormous changes in the human condition.

The third singularity

The third candidate is science, and the development of the scientific method.

It may seem odd to put in the list something that took place through many discrete and measurable stages, something that seems totally abstract compared with the tangible developments of fire and agriculture.

But revolutions in thought are just as real in their effects as practical inventions. It is true that when we say "science" we are looking at a whole succession of developments. They include Babylonian astronomy, Greek geometry, Renaissance mechanics, Copernicus with his (literally) revolutionary ideas about the Earth and sun, Newton, Darwin, Pasteur, and Einstein. We see these discrete points all through history and can

argue there was no point of time when science "arrived." But we see science as a succession of changes, and fire and agriculture as "events," only because the latter two took place before recorded history. We have no idea how many generations it took to tame fire. And the mastery of the techniques of agriculture must have been an equally difficult struggle. The mental leap from the small seed in the spring to the full plant, months later, was an astonishing one. It must have occupied the early experimenters for hundreds of years. Had the scientific method somehow developed before writing, we would probably in our discussions today refer to "the coming of science", exactly as though it had sprung full-blown from the brain of a single individual, at a single moment of time.

Science has been with us in one form or another for thousands of years. However, the time when the multiple effects of science on everyday Western life became unavoidable arrived quite recently. It began roughly two hundred years ago, and the rate of science-induced change shows no sign of decreasing; it is almost certainly increasing, and increasing *at an increasing rate*. Today no human activity in the western hemisphere is unaffected by scientific developments.

Abstract science has had two great effects on human affairs. On the practical side, there is science's continuing role as a stimulus and source of new ideas for technology. Conversely, today's scientific advances depend heavily on advanced technology. You can't separate science and technology, much as some people would love to be able to do so. Science and technology are inextricably linked, and we can no longer conceive of one without the other.

On the philosophical side, science liberated us from a pattern of thought that must have been as old as humanity. With the rise of science and the scientific method, people began to realize that gods and devils and elves and goblins and magic and mysticism are not inevitable components of life. It is possible to understand the external universe and manipulate it as well—or

a whole lot better—without the trappings of the supernatural. That must have been a great surprise, because for many thousands of years humans had thought that the universe and our destinies were controlled by the gods, and by numerous separate gods. The idea that no one is looking after us—that if we don't do it for ourselves, then no one will—must have been a horrible shock.

It's a revelation that many people deny today. But we have to learn to accept the unpleasant fact: we can't look for an intervention by Jove or Aphrodite or any of the other luminaries of the Greek or Roman pantheon to get us out of any fix we're in.

At the same time science told us we have responsibility for our own problems, it made us realize that we are far less central in the cosmic picture than we had thought. Science taught us—a lesson we have still not learned very well—humility. Earth lost its position as the center of the universe. It went first to being one of several planets around the sun. Then the sun was found not to be the center of the universe, either, and Earth became a rather puny satellite of an undistinguished star in a galaxy of 100 billion stars. Then the final blow, our galaxy was found to be nothing but a rather average specimen in a population of 100 billion galaxies.

Another unpleasant change in our self-image came at roughly the same time. Instead of being the lords of creation—a comforting but dangerous delusion—we found ourselves close kin to rats, monkeys, sponges, jellyfish, turnips and coconuts. If Copernicus dethroned Earth as the center of the universe, Darwin did the same for mankind.

Many people find that hard to accept, too. People who dislike science often do so because they think that science diminishes man. I don't agree. I think that science teaches us our proper place in the universe, rather than giving us an oddly inflated idea of what we are. But if you happen to be a scientific creationist (unlikely, since I do not look for that group as my audience; I like

readers who can think) then you still hold the primitive view that mankind is uniquely important.

Perhaps mankind is—but not for what we are, or what we have done; for what, in the long run, we may do.

The fourth singularity

Fire, agriculture, science. There are many other candidates for the irreversible agents of change. I reject most of them as being of a lower level of importance. I reject the wheel, the printing press, steam, nuclear energy, electronics. All significant, all important, but not the overwhelming instruments of change that we are looking for. Let us reserve judgment about computers. It's too early to tell. They may be one of the true singularities in human history, and I rather think they are, but we have only 40 years of experience to go on—in the time scales we are talking of, that's absolutely nothing.

I also reject two others: religion and language. But we need to discuss them a little further.

First, language. Language is one of the absolutely fundamental influences on human life; but I believe, along with Noam Chomsky, that language capability is hard-wired into us as a "universal grammar." It is not a human invention or discovery (it's estimated that an I.Q. of 50 is enough to let a person learn a first language.)

However, if I say not simply language, but *recording and language*, then we have something completely different. My fourth candidate for the major change factor of human history is *the ability to record what we have learned*.

Today we not only communicate in person; we can talk to any succeeding generation, and pass along to them anything significant that we have learned. The reason we know nothing of the origins of fire and agriculture is not that people have poor memories. I suspect that pre-literate man had a much better memory

than most of us possess today. But although word-of-mouth can serve you well over a few generations, it turns out to be totally useless over a span of thousands of years. What we know about ancient Egypt is gained from their writings and drawings, not from any oral transmission of information.

With recording methods, written and others, we acquired a race memory. There were obviously great geniuses ten thousand years ago; we know nothing about them. But we will probably know what Einstein thought, for as long as the species endures. Somatic memory—the information passed down to us in our genetic material—and cerebral memory have been supplemented by library memory.

Religion is another matter. I am not religious. The words and teachings of Christ and Buddha are wise and beautiful, but I find they have little to do with organized religion. The latter unfortunately seems to have been responsible for much of human misery over the centuries.

At the same time, I certainly do not deny the importance of religion on human affairs. That would be ridiculous. Religions have been important ever since the species developed self-awareness. However, organized religion tends to serve as an instrument of *stability*, of *status quo*, rather than one of change. And religion provides one of the few invariants in human existence. Thus it is unlikely to provide a timeline singularity.

The fifth singularity

I have one other candidate for an instrument of fundamental change. It is one that I wish I did not have to put in the list, but it cannot be ignored.

The fifth candidate is global war. We have had wars since the first territorial squabbles of primitive man. But modern, organized, global war is different.

Consider its properties. First, modern war is impersonal. In the old days, the soldier could see and per-

haps even know and sympathize with the enemy that he was expected to fight and kill. But modern war removes the human contact, and hence the possibility of any empathy with the foe. War was never pleasant, but modern war is dehumanized.

Second, modern war is *total*. It involves everyone. In the old days, there was a chance that the fighting would stay away from your door. The armies would march away, and a few days or weeks later there would come news of victory or defeat. Often, the non-soldier was little affected by the outcome. The taxes imposed by the new king were likely to look much the same as those imposed by the old one.

We no longer have that distant meeting of armies, or of individual champions. Now war can affect every person in the world.

Third, modern war no longer calls for qualities of human strength and endurance. We may not like any form of war, but at least the old forms made use of innately human attributes. That began to go away with the invention of weapons and armor. It disappeared totally with the invention of long-range weapons delivery systems. Again, the dehumanizing element of war increased.

I should add a fourth attribute that worries me particularly. In the old days, the kings and generals were in the front line of battle. If anyone was killed, they were the prime target and were likely to go first. Harold died at Hastings, Nelson at Trafalgar. But modern generals and politicians are like the Duke of Plaza-Toro, in Gilbert and Sullivan's "The Gondoliers" ("He led his regiment from behind—he found it less exciting.") The admirals and the senators are far from the front line, and they are the best protected of anyone. It gives me little comfort to know that the group making the decision, war or no war, has made arrangements to direct operations from lead-lined rooms thousands of feet below ground.

Modern, organized, total, global war must be included as a *potential* timeline singularity—and let us

hope that it never realizes that potential. If it does it may be less a singularity of humanity's timeline, than the total end of the line.

Modern war is the only one of the singularities with the power to wipe out human civilization, quickly and finally.

The sixth critical point

We stand today at the brink of another critical point. It will affect the future as profoundly as fire, as agriculture, as science, as recorded thought, as worldwide war. If we look at the previous examples and ask, can we draw from them a set of properties common to them all, we will note these common features:

(1) They all affect everyone. No one escapes. You might say, what about the remaining primitive tribes in New Guinea, or in the Kalahari Desert? They don't practice agriculture, they don't know science, they don't have written recording of information. True. And they will, unless they are absorbed into the rest of humanity, undoubtedly become extinct. The rest of the world is invading their environment. The primitive society may know nothing of nuclear fusion—but if there should be a global conflict, ignorance will not bring immunity.

(2) They are irreversible. "The moving finger writes; and having writ, moves on; nor all thy piety nor wit shall lure it back to cancel half a line, nor all thy tears wash out a word of it." You can't go home again; once you pass through a singularity there can be no returning. The world is changed forever.

(3) I have referred to these events as singularities. That word was chosen carefully. One of the important points about a mathematical singularity is that you cannot continue the series expansion of a function through it; the behavior on the other side of the singularity cannot be predicted from a knowledge of what it does on this side. In other words, no matter how smart we are, there is no way we can guess what the world will

be like on the future side of a true singularity—which is why futurists often succeed on the minor changes, and always miss totally in predicting the major ones. I'm afraid I class futurists with meteorologists and economists when it comes to the value and accuracy of their predictions.

It is not a question of intelligence. We can't conceive of the new world, any more than people before agriculture could conceive of large cities, of grain stockpiling, of crop commodities forecasting, or of a country with so much food capacity that its farmers had to be paid *not* to grow. They were certainly as intelligent as we are. But they lacked the relevant knowledge base. Past knowledge, no matter how complete and accurate, is not enough for accurate projection whenever we are looking out across a timeline singularity.

4) There is no such thing as a technological change. Any major change of a technological nature will, like it or not, produce dramatic social changes. If you tell me of some technological advance which will leave the basic fabric of the world unchanged, then my response is, that is minor technology—no matter how useful it may be to us personally.

Singularities of the past were not predicted. How then can a plausible claim be made that we will encounter one in the near future?

I am convinced only that *some* singularity is on the way. And I argue that one of two developments is overwhelmingly likely to happen, well within the next century. I cannot speculate on which branch of the future we are likely to follow, though one of them is clearly preferable to the other.

The driving forces for dramatic change in humanity's overall condition are already operating. They are as follows:

1) The Earth is finite. There will be no "New-found-land," no new earthly continents that we can escape to or develop. Mark Twain's advice: "Buy land, they're not making it any more," is still good. They're still not making it. "Go West, young man," no longer applies as

a piece of advice that will take you to a region unspoiled and apparently endless in new lands and resources.

2) Earth is not quite fully explored, but it is already close to fully exploited. We may be getting close to the capacity of the land and the sea to serve as dumping grounds for our waste products. Our planetary resources are bounded, and we are already meeting the bounds. We have treated Earth through history as though it were an infinite reservoir. The overall biological system of Earth was considered in stable equilibrium—perturb it in any way from its initial state, and it will return to it. The plants will grow again, spring will return. But at this point of planetary use, the world no longer looks infinite to us.

We are looking at the possibility of irreversible changes. Some people have gone so far as to suggest that our present policies, burning the fossil fuels and removing the topsoil, could induce a change to Earth that will eventually lead it to the same condition as Venus—lifeless, with temperatures hot enough to melt lead, no free oxygen, clouds of sulfuric acid.

3) We live with a constant threat of nuclear war. "Constant threat" is an interesting notion. It doesn't take much mathematics to show that if the probability of an event happening during one year is constant and non-zero, the probability that it will happen *sometime* approaches certainty if the time period considered is long enough.

In other words, if nothing changes in the world situation, nuclear war is not merely possible, it is *inevitable*.

On this subject, past prophesiers have fortunately so far been wrong. C.P. Snow stated in 1959 that nuclear war "has to happen within 20 years." It didn't—yet. But it could, tomorrow. And if ever it does, our descendants, if there are any such, will look back and say, "Of course, it had to happen, it was absolutely inevitable. How could it *not* happen, when people were constantly building and stockpiling such arsenals of total destruction?"

4) We cannot pretend that we live in a constant

world, even if we ignore the daily addition to our weapons supply. The world population continues to grow, and grow fast. The global count is about 4.7 billion now. It is projected to be about 6.5 billion by the turn of the century, and it will still be rising steadily at that time. No matter what we do here on Earth, if the population just keeps on growing we'll run out of room and resources. That's not a new idea. It goes back to 1798, when Thomas Malthus wrote his famous "Essay On Population." He simply pointed out that people can breed in a geometric progression, whereas food supplies in the long run increase at best as an arithmetic progression. Eventually, the geometric progression always grows faster. Starvation wins.

Critics of the Malthusian doctrine argue that Malthus's argument is flawed in three fatal ways. First, history has already proved it wrong. According to the ideas of food production capacity held at the beginning of the nineteenth century, the world could not grow enough food to support its present population. There is enough food in the world today, though it is poorly distributed. Second, there is no reason why food could not in the future be synthesized from basic raw materials. It does not need to be *grown*. Thus arguments that we are running out of available crop acreage are spurious. Third, there is no reason why the population has to keep on increasing. The average family size in the technologically advanced nations is much smaller than it used to be, and as other nations become more advanced they will probably see a similar slowing in population growth.

The first two arguments may well be right; Malthus has been wrong, so far, and we may be able to synthesize ample food—though such synthesis will undoubtedly have waste products, and we will have the problem of disposing of those. But neither of the first two points is relevant if the population continues to grow. Unless zero population growth is reached, we will eventually run out of living space. And if we manage to limit our own population growth before we are forced to do so by external circumstances, we will be the first species ever

to achieve such a limitation. The psychological effects of overcrowding have been studied in animal populations; lack of living space leads to belligerence and unstable behavior. You might say we are already seeing the first signs of these problems in our own culture.

My own feeling is that Malthus may be wrong, but the chance that he is right is fairly high. We can't gamble our future on the assumption that everything will work out fine, without our needing to worry about it. That's the modern equivalent of waiting for Jove to send a thunderbolt in just the place where it is needed. The only safe procedure is to assume that Malthus may be right: that we have to solve this problem ourselves, and to plan accordingly.

For all the above reasons, the *status quo* is unlikely to be maintained. There will be change, and dramatic change.

But what can change, to add some hope to our gloomy prospects? Human nature?

That's certainly desirable, and it's certainly unlikely. Through all the changes of the past few thousand years, the one totally invariant element seems to have been human attitudes. We still intrigue, fight, love, lie and laugh as inconsistently and as vigorously as we ever did. Events in Greece or Rome could be happening yesterday. I'd hate to pin my chances of long-term survival on the assumption of a fundamental change in human nature and human behavior.

I see three options, three branches to our future.

First, we may blow ourselves up. That is still quite probable.

Second, we may be forced to accept a diminished lifestyle. If that happens, as Arthur Clarke put it, "Humanity will have turned its back upon the still untrodden heights and will be descending again the long slope that stretches, across a thousand million years of time, down to the shores of the primeval sea." I regard this future as very unlikely, because the political pressures in a future of diminished expectations are all too likely to lead us to global war.

Or we can decide that the source of our problems is that we are still looking at Earth as though it were the whole universe. That was the great fallacy implicit in the "Global 2000" and "Limits to Growth" studies of the 1960s and '70s. They saw Earth's problems in the context of a solution provided wholly by the resources of Earth. Those analyses came, not surprisingly, to a pessimistic and grim conclusion: of war, a diminished life-style, or both.

There is an another future available. Mankind can explore space, and develop the resources of space.

This does *not* mean we will ship the excess population to live in space habitats. That has never worked in the past, and it won't work now. All that happens is that the people left behind keep right on breeding, and before you know it the population is climbing steadily again. Humans may not be good at many things, but they are good at breeding.

We won't solve Earth's problems by escaping from them. We will solve them by using space and the resources of the whole solar system. That move of humanity's focus from an Earth-oriented to a Solar System-oriented one offers a future that leads neither to global war nor to subsistence-level survival. It leads to wealth and prosperity, not annihilation or decline.

This development of off-Earth resources has to come. And it has to come soon. We don't have the hundreds of centuries available that our ancestors could devote to the mastery of fire and agriculture. The nuclear arsenal is ticking quietly away, time bombs deep within the United States and the Soviet Union. We are all participants in a great, grim race: the race between space development and global war.

Can this race be won, and the future be assured? I think it can. For as Dennis Gabor pointed out, "The future cannot be predicted, but futures can be invented."

It is our job to invent it, to *create* the future that we want. We have to make sure that space development is the next singularity in the history of the human species.

IRON

I have one sure-fire method for making a roomful of sf fans gasp in audible lust: tell them about Larry Niven's shared universe project, The Man-Kzin Wars. At Larry's invitation, a small group of authors, including Poul Anderson, John Dalmás—and of course Jerry Pournelle—have undertaken to "flesh out" a relatively untouched section of Larry's Known Universe future history, the period when humans faced and beat the reflexively warlike tigeroids known as the Kzinti.

*Here is the first fruit of their labors: Part I of "Iron." To be continued next issue.**

—JPB

** Note that we are changing our name: This is the last issue of Far Frontiers: look for Part II of "Iron" in a remarkably similar magazine in book format called New Destinies!*

IRON

Poul Anderson

1

The kzin screamed and leaped.

In any true gravity field, Robert Saxtorph would have been dead half a minute later. The body has its wisdom, and his had been schooled through hard years. Before he really knew what a thunderbolt was coming at him, he had sprung aside—against the asteroid spin. As his weight dropped, he thrust a foot once more to drive himself off the deck, strike a wallfront, recover control over his mass, and bounce to a crouch.

The kzin was clearly not trained for such tricks. He had pounced straight out of a crosslane, parallel to Tiamat's rotation axis. Coriolis force was too slight to matter. But instead of his prey, he hit the opposite side of Ranzau Passage. Pastel plastic cracked under the impact; the metal behind it boomed. He recovered with the swiftness of his kind, whirled about, and snarled.

For an instant, neither being moved. Ten meters from him, the kzin stood knife-sharp in Saxtorph's awareness. It was as if he could count every red-orange hair of the pelt. Round yellow eyes glared at him out of the catlike face, above the mouthful of fangs. Bat-wing ears

were folded out of sight into the fur, for combat. The naked tail was angled past a columnar thigh, stiffly held. The claws were out, jet-black, on all four digits of either hand. Except for a phone on his left wrist, the kzin was unclad. That seemed to make even greater his 250 centimeters of height, his barrel thickness.

Before and behind the two, Ranzau Passage curved away. Windows in the wallfronts were empty, doors closed, signs turned off; workers had gone home for the nightwatch. They were always few, anyway. This industrial district had been devoted largely to the production of spaceship equipment which the hyperdrive was making as obsolete as fission power.

There was no time to be afraid. "Hey, wait a minute, friend," Saxtorph heard himself exclaim automatically, "I never saw you before, never did you any harm, didn't even jostle you—"

Of course that was useless, whether or not the kzin knew English. Saxtorph hadn't adopted the stance which indicated peacefulness. It would have put him off balance. The kzin bounded at him.

Saxtorph released the tension in his right knee and swayed aside. Coming upspin, his speed suddenly lessening his weight, the kzin—definitely not a veteran of space—went by too fast to change direction at once. As he passed, almost brushing the man, the gingery smell of his excitement filling the air, Saxtorph thrust fingers at an eye. That was just about the only vulnerable point when a human was unarmed. The kzin yowled; echoes rang.

Saxtorph was shouting too, "Help, murder, help!" Somebody should be in earshot of that. The kzin skidded to a halt and whipped about. It would have been astounding how quick and agile his bulk was, if Saxtorph hadn't seen action on the ground during the war.

Again saving his breath, the man backed downspin, but slantwise, so that he added little to his weight. Charging full-out, the kzin handicapped himself much more. The extra drag on his mass meant nothing to his muscles, but confused his reflexes. Dodging about,

Saxtorph concentrated first on avoiding the sweeps of those claws, second on keeping the velocity parameters unpredictably variable. From time to time he yelled.

One slash connected. It ripped his tunic from collar to belt, and the undershirt beneath. Blood welled along shallow gashes. As he jumped clear, Saxtorph cracked the blade of his hand onto the flat nose before him. It did no real harm, but hurt. The kzin's eyes widened. The pupil of the undamaged one grew narrower yet. He had seen the scars across his opponent's chest. This human had encountered at least one kzin before, face to face.

But Saxtorph was 15 years younger then, and equipped with a Gurkha knife. Now the wind was gusting out of him. His gullet was afire. Sluggishness crept into his motions. "Ya-a-ah, police, help! Ki-yai!"

A whistle skirled. The kzin halted. He stared past Saxtorph. The man dared not turn his head, but he heard cries and footfalls. The kzin turned and sped in the opposite direction, upspin. He whirled into the first crosslane he came to and disappeared.

And *that* wasn't like his breed, either. Saxtorph sagged back against a wallfront and sobbed breath into his lungs. Sweat was cold and acrid on him. He felt the beginnings of the shakes and started calling calm down on himself, as the Zen master who helped train him for war had taught.

One cop waved off a score or so of people whom the commotion had drawn after him and his companion. The other approached Saxtorph. He was stocky, clean-shaven, unremarkable except for the way he cocked his ears forward—neither aristocrat nor Belter, just a commoner from Wunderland. "*Was ist hier los?*" he demanded somewhat wildly.

Saxtorph could have recalled the Danish of his childhood, before the family moved to America, and brushed the rust off what German he'd once studied, and made a stab at this language. The hell with it. "Y-y-you speak English?" he panted.

"Ja, some," the policeman answered. "Vat is t'is? Don't you know not to push a kzin around?"

"I sure do know, and did nothing of the sort." Steadiness was returning. "He bushwhacked me, completely unprovoked. And, yes, this sort of thing isn't supposed to happen with kzinti, and I can't make any more sense of it than you. Aren't you going to chase him?"

"He's gone," said the policeman glumly. "He vill be back in Tigertown and t'e trail lost before ve can bring a sniffer to follow him. How you going tell vun of t'ose *Teufel* from anot'er? You come along to t'e station, sir. Ve vill give you first aid and take your statement."

Saxtorph drew a long breath, grinned lopsidedly, and replied, "Okay. I'll want to make a couple of phone calls. My wife, and—it'd be smart to ask Commissioner Markham if I can put off my appointment with him."

2

Tiamat is much less known outside its system than it deserves to be. Once hyperdrive transport has become readily available and cheap, it may well be receiving tourists from all of human space: for it is a curious object, with considerable historical significance as well.

Circling Alpha Centauri A near the middle of those asteroids called the Serpent Swarm, it was originally a chondritic body with a sideritic component giving it more structural strength than is usual for that kind. A rough cylinder, about 50 kilometers in length and 20 in diameter, it rotated on its long axis in a bit over ten hours; and at the epoch when humans arrived, that axis happened to be almost normal to the orbital plane. Those who settled on Wunderland paid it no attention; they had a habitable planet. The Belters who came later, from the asteroids of the Solar System, realized what a treasure was theirs. Little work was needed to make the cylinder smooth, control precession, and give it a centrifugal acceleration of one *g* at the circumference. With its axial orientation, the velocity changes for

spacecraft to dock were minimal, and magnetic anchors easily held them fast until they were ready to depart. The excavation of rooms and passages in the yielding material went rapidly. Thereafter, spaces just under the surface provided Earth-weight for such activities as required it, including the bringing of babies to term; farther inward were the levels of successively lower weight, where Belters felt comfortable and where other undertakings were possible.

Everywhere around orbited members of the Swarm, their mineral wealth held in negligible gravity wells. Tiamat boomed. It became an industrial center, devoted especially to the production of things associated with spacefaring.

When the kzinti invaded, they were quick to realize its importance. Their introduction of the gravity polarizer changed many of the manufacturing programs, but scarcely affected Tiamat itself; one seldom had any reason to adjust the field in a given section, since one could have whatever weight was desired simply by going to the appropriate level.

Out of the years that followed have come countless stories of heroism, cowardice, resistance, collaboration, sabotage, salvage, ingenuity, intrigue, atrocity, mercy. Some are true. Certainly, when the human hyperdrive armada entered the Centaurian System, Tiamat might well have been destroyed, had not the Belter freedom fighters taken it over from within.

So ended its heroic age. The rest is anticlimax. More and more, new technologies and new horizons are making it a relic.

However, it is still populous and interesting. Not least of its attractions, though a mixed blessing, are the kzinti. Of those who stayed behind at this sun, or actually sought there, after the war—disgraced combatants, individuals who had formed ties too strong to break, Kdaptist refugees, eccentrics, and others less understandable—a goodly proportion have their colony within Tiamat. Tigertown is well worth visiting, in a properly briefed tour group with an experienced guide.

Tiamat also contains the headquarters of the Interworld Space Commission, which likewise is not as much in the awareness of the general public as it ought to be. Now that the hyperdrive has abruptly opened a way to far more undertakings than there are ships and personnel to carry out, rivalry for those resources often gets bitter. It can become political, planet versus planet at a time when faster-than-light travel has made peace between them as necessary as peace between nations on Earth had become when humankind was starting its outward venture. Until we have created enough capability to satisfy everyone, we must allocate. Alpha Centauri—Wunderland, parts of the Serpent Swarm—alone among human dwelling places, suffered kzin occupation, almost half a century of it. Alpha Centaurian men and women endured, or waged guerrilla warfare from remote and desolate bases, until the liberation. Who would question *their* dedication to our species as a whole?

At least, it was an obvious symbolism to make them the host folk of the Commission; and Tiamat, not yet into its postwar decline, was a natural choice for the seat.

3

"Good evening," replied Dorcas Glengarry Saxtorph. The headwaiter had immediately identified her as being from the Solar System and greeted her in English. "I was to meet Professor Tregennis. The reservation may be in the name of Laurinda Brozik." You didn't just walk into the Star Well; it was small and expensive.

Very briefly, his smoothness failed him and he let his gaze linger. Ten years after the end of the war, when outworlders had become a substantial fraction of the patronage, she was nonetheless a striking sight. A Belter, 185 centimeters in height, slender to the point of leanness, she was not in that respect different from those who had inhabited the Swarm for generations. How-

ever, you seldom met features so severely classic, fair-skinned, with large green eyes under arching brows. The molding of her head was emphasized by the Sol-Belter style, scalp depilated except for a crest of mahogany hair that in her case swept halfway down her back. A shimmery gray gown folded and refolded itself around carriage and gestures which, even for a person of spacer ancestry, were extraordinarily precise.

The headwaiter regained professionalism. "Ah, yes, of course, madame." Dorcas didn't show her forty Earth-years much, but nobody would take her for a girl. "This way, please."

The tables were arranged around a sunken transparency, ten meters across, which gave on the surface of Tiamat and thus the sky beyond. Nonreflecting, in the dim interior light it seemed indeed a well of night which the stars crowded, slowly streaming. The table Dorcas reached was on the bottom tier, with a view directly down into infinity. A glowlamp on it cast softness over cloth, silver, ceramic, and the two people already seated.

Arthur Tregennis rose, courtly as ever. A Plateaunian of Crew descent, the astrophysicist stood as tall as she did and still more slim, practically skeletal. He had the flared hook nose and high cheekbones of his kindred; the long nail on his left little finger proclaimed him an aristocrat of his planet, never subject to manual labor. Dorcas sometimes wondered why he kept that affectation, when he admitted to having sympathized with the democrats and their revolution, 33 years ago. Habit, perhaps. Otherwise he was an unassuming old fellow.

"Welcome, my lady," he said. His English was rather flat. Since the advent of hyperdrive and hyperwave, he'd been to so many scientific conferences, or in voice-to-voice contact with colleagues, that native accent seemed to have worn off—except, maybe, when he was with his own folk on top of Mount Lookitthat. "Ah, is Robert detained?"

"I'm afraid so." Dorcas let the waiter seat her. She'd reacquired a little sophistication since the war. "He had

a nasty encounter, and the aftermath is still retro on him. He told me to come alone, give you his regrets, and bring back whatever word you have for us."

"Oh, dear," Laurinda Brozik whispered. "He's all right, isn't he?"

The English of Tregennis' graduate student was harder for Dorcas to follow than his. It was from *We Made It*. The young woman was not a typical Crashlander—is there any such thing as a typical anything?—but she could not have been mistaken for a person from anywhere else. Likewise tall and finely sculptured, she seemed attenuated, arachnodactylic, somehow both awkward and eerily graceful, as if about to go into a contortion such as her race was capable of. She belonged to the large albino minority on the planet, with snowy skin, big red eyes, white hair combed straight down to the shoulders. In contrast to Tregennis' quiet tunic and trousers, she wore a gown of golden-hued fabric—an expert would have identified it as Terrestrial silk—and an arrowhead pendant of topaz; but somehow she wore them shyly.

"Well, he survived, not too upset." Glancing at the waiter, Dorcas ordered a dry martini, "—and I mean *dry*." She turned to the others. "He was on his way to talk with Markham," she explained. "Late hour, but the commissioner said he was too busy to receive him earlier. In fact, the meeting was to be at an auxiliary office. The equipment at the regular place is all tied up with—I'm not sure what. Well, Bob was passing through a deserted section when a kzin came out of nowhere and attacked him. He kept himself alive, without any serious damage, till the noise drew the police. The kzin fled."

"Oh, dear!" Laurinda repeated. She looked appalled.

Tregennis had a way of attacking problems from unexpected angles. "Why was Robert on foot?" he asked.

"What?" said Dorcas, surprised. She considered. "The tubeway wasn't convenient for his destination, and it's not much of a walk. What of it?"

"There have been ample incidents, I hear. Kzinti

with their hair-trigger tempers; and many humans bear an unreasoning hatred of them. I should think Robert would take care." Tregennis chuckled. "He's too seasoned a warrior to want any trouble."

"He had no reason to expect any, I tell you." Dorcas curbed her irritation. "Never mind. It was doubtless just one of those things. He has a ruined tunic and four superficial cuts, but he gave as good as he got. The point is, the police are in an uproar. They were nervous enough, now they're afraid of more fights. They've kept him at the station, questioning him over and over, showing him stereograms of this or that kzin—you can imagine. When last he called, he didn't expect to be free for another couple of hours, and then, on top of having nearly gotten killed, he'll be wrung out. So he told me to meet you on behalf of us both."

"Horrible," Laurinda said. "But at least he is safe."

"We regret his absence, naturally," Tregennis added, "and twice so when we had invited you two to dinner here in celebration of good news."

Dorcas smiled. "Well, I'll be your courier. What is the message?"

"It is for you to tell, Laurinda," the astrophysicist said gently.

The girl swallowed, leaned forward, and blurted, "This mornwatch I got the word I'd hoped for. On the hyperwave. My father, he, he'd been away, and afterward I suppose he needed to think about it, because that is a lot of money, but—but if necessary, he'll give us a grant. We won't have to depend on the Commission. We can take off on our own!"

"Wow-oo," Dorcas breathed.

Though it made no sense, for a tumbling few seconds her mind was on Stefan Brozik, whom she had never met. He had been among those on *We Made It* quickest to seize the chance when the Outsiders came by with their offer to sell the hyperdrive technology. For a while he was an officer in one of the fleets that drove the kzin sublight ships back and back into defeat. Returning, he made his fortune in the production of

hyperdrives for both government and private use; and Laurinda was his adored only daughter—

"It will take a time," came Tregennis' parched voice. "First the draft must clear the banks, then we must order what we need and wait for delivery. The demand exceeds the supply, after all. However, in due course we will be able to go."

His white head lifted. Dorcas remembered what he had said to Markham, when the commissioner declared: "Professor, this star of yours does appear to be an interesting object. I do not doubt an expedition to it would have scientific value. But space is full of urgent work to do, human work to do. Your project can wait another ten or fifteen years."

Iron had been in Tregennis' answer: "I cannot."

"Wonderfull!" exclaimed Dorcas. Her jubilation was moderate merely because she had expected this outcome. The only question had been how long it would take. Stefan Brozik wouldn't likely deny his little girl a chance to go visit the foreign sun which she, peering from orbit around Plateau, had discovered, and which could make her reputation in her chosen field.

Nonetheless, Dorcas' gaze left the table and went off down the well of stars. Alpha Centauri B, dazzling bright, had drifted from it. She had a clear view toward the Lesser Magellanic Cloud. In yonder direction lay Beta Hydri, and around it swung Silvereyes, the most remote colony that humankind had yet planted. Beyond Silvereyes—But glory filled vision. Laurinda's sun was a dim red dwarf, invisible to her. Strange thought, that such a thing might be a key to mysteries.

Anger awoke. "Maybe we won't need your father's money," Dorcas said. "Maybe the prospect will make that slime-bugger see reason."

"I beg your pardon?" asked Tregennis, shocked.

"Markham." Dorcas grinned. "Sorry. You haven't been toe-to-toe with him, over and over, the way Bob and I have. Never mind. Don't let him or a quantum-headed kzin spoil our evening. Let's enjoy. We're going!"

The office of Ulf Reichstein Markham was as austere as the man himself. Apart from a couple of chairs, a reference shelf, and a desk with little upon it except the usual electronics, its largeness held mostly empty space. Personal items amounted to a pair of framed documents and a pair of pictures. On the left hung his certificate of appointment to the Interworld Space Commission and a photograph of his wife with their eight-year-old son. On the right were his citation for extraordinary heroism during the war and a portrait painting of his mother. Both women showed the pure bloodlines of Wunderland aristocracy, the older one also in her expression; the younger looked subdued.

Markham strove to maintain the same physical appearance. His father had been a Belter of means, whom his mother married after the family got in trouble with the kzinti during the occupation and fled to the Swarm. At age 50 he stood a slender, swordblade-straight 195 centimeters. Stiff gray-blond hair grew over a narrow skull, above pale eyes, long nose, outthrust chin that sported the asymmetric beard, a point on the right side. Gray and close-fitting, his garb suggested a military uniform.

"I trust you have recovered from your experience, Captain Saxtorph," he said in his clipped manner.

"Yah, I'm okay, aside from puzzlement." The spaceman settled back in his chair, crossed shank over thigh. "Mind if I smoke?" He didn't wait for an answer before reaching after pipe and tobacco pouch.

Markham's lips twitched the least bit in disdain of the uncouthness, but he replied merely, "We will doubtless never know what caused the incident. You should not allow it to prey on your mind. The resident kzinti are under enormous psychological stress, still more so than humans would be in comparable circumstances. Besides uprootedness and culture shock, they must daily live with the fact of defeat. Acceptance runs counter to an instinct as powerful in them as sexuality is in hu-

mans. This individual, whoever he is, must have lashed out blindly. Let us hope he doesn't repeat. Perhaps his friends can prevail on him."

Saxtorph scowled. "I thought that way too, at first. Afterward I got wondering. I hadn't been near any kzinti my whole time here, this trip. They don't mingle with humans unless business requires, and then they handle it by phone if at all possible. This fellow was way off the reservation. He lurked till I arrived, in that empty place. He was wearing a phone. Somebody else, shadowing me, could have called to tell him I was coming and the coast was clear."

"Frankly, you are being paranoid. Why in creation should he, or anyone, wish you harm? You specifically, I mean. Furthermore, conspiracy like that is not kzin behavior. It would violate the sense of honor that the meanest among them cherishes. No, this poor creature went wandering about, trying to walk off his anger and despair. When you chanced by, like a game animal on the ancestral planet passing a hunter's blind, it triggered a reflex that he lost control of."

"How can you be sure? How much do we really know about that breed?"

"I know more than most humans."

"Yah," drawled Saxtorph, "I reckon you do."

Markham stiffened. His glance across the desk was like a levelled gun. For a moment there was silence.

Saxtorph got his pipe lit, blew a cloud of smoke, and through it peered back in more relaxed wise. He could afford to; somatic presence does make a difference. Barely shorter than the Wunderlander, he was hugely broader of shoulders and thicker of chest. His face was wide, craggy-nosed, shaggy-browed, with downward-slanted blue eyes and reddish hair that, at age 45, was getting thin. Whatever clothes he put on, they soon looked rumpled, but this gave the impression less of carelessness than of activity.

"What are you implying, Captain?" Markham asked low.

Saxtorph shrugged. "Nothing in particular, Commis-

sioner. It's common knowledge that you have quite a lot to do with 'em."

"Yes. Certain among the rabble have called me 'kzin-lover.' I did not believe you shared their sewer mentality."

"Whoa, there." Saxtorph lifted a palm. "Easy, please. Of course you'd take a special interest. After all, the kzin empire, if that's what we should call it, it's still out yonder, and we still know precious little about it. Besides handling matters related to kzin comings and goings, you have to think about the future in space. Getting a better handle on their psychology is a real service."

Markham eased a bit. "Learning some compassion does no harm either," he said unexpectedly.

"Hm? Pardon me, but I should think that'd be extra hard for you."

Markham's history flitted through Saxtorph's mind. His mother had apparently married his commoner father out of necessity. Her husband died early, and she raised their son in the strictest aristocratic and martial tradition possible. By age 18 Markham was in the resistance forces. As captain of a commando ship, he led any number of raids and gained a reputation for kzin-like ruthlessness. He was 30 when the hyperdrive armada from Sol liberated Alpha Centauri. Thereafter he was active in restoring order and building up a Wunderland navy. Finally leaving the service, he settled on the planet, on a restored Reichstein estate granted him, and attempted a political career; but he lacked the needful affability and willingness to compromise. It was rumored that his appointment to the Space Commission had been a way of buying him off—he had been an often annoying gadfly—but he was in fact well qualified and worked conscientiously.

The trouble was, he had his own views on policy. With his prestige and connections, he had managed in case after case to win agreement from a voting majority of his colleagues.

Saxtorph smiled and added, "Well, Christian charity is all the more valuable for being so rare."

Markham pricked up his ears. The pale countenance

flushed. "Christian!" he snapped. "A religion for slaves. No, I learned to respect the kzinti while I fought them. They were valiant, loyal, disciplined—and in spite of the propaganda and horror stories, their rule was by no means the worst thing that ever happened to Wunderland."

He calmed, even returned the smile. "But we have drifted rather far off course, haven't we? I invited you here for still another talk about your plans. Have I no hope of persuading you the mission is wasteful folly?"

"You've said the same about damn near every proposal to do any real exploring," Saxtorph growled.

"You exaggerate, Captain. Must we go over the old, trampled ground again? I am simply a realist. Ships, equipment, trained crews are in the shortest supply. We need them closer to home, to build up interstellar commerce and industry. Once we have that base, that productivity, yes, then of course we go forward. But we will go cautiously, if I have anything to say about it. Was not the kzin invasion a deadly enough surprise? Who knows what dangers, mortal dangers, a reckless would-be galaxytrotter may stir up?"

Saxtorph sighed. "You're right, this has gotten to be boringly familiar territory. I'll spare you my argument about how dangerous ignorance can be. The point is, I never put in for anything much. For a voyage as long as we intend, we need adequate supplies, and our insurance carrier insists we carry double spares of vital gear. The money Professor Tregennis wangled out of his university for the charter won't stretch to it. So we all rendezvoused here to apply for a government donation of stuff sitting in the warehouses.

"It just might buy you a scientific revolution."

He had rehashed this with malice, to repay Markham for the latter's own repetition. It failed to get the man's goat. Instead, the answer was, mildly, "I saw it as my duty to persuade the Commission to deny your request. Please believe there was no personal motive. I wish you well."

Saxtorph grinned, blew a smoke ring, and said,

"Thanks. Want to come wave goodbye? Because we are going."

Markham took him off guard with a nod. "I know. Stefan Brozik has offered you a grant."

"Huh?" Saxtorph grabbed his pipe just before it landed in his lap. He recovered his wits. "Did you have the hyperwave monitored for messages to members of our party?" His voice roughened. "Sir, I resent that."

"It was not illegal. I was . . . more concerned than you think." Markham leaned forward. "Listen. A man does not necessarily like doing what duty commands. Did you imagine I don't regret choking off great adventures, that I do not myself long for the age of discovery that must come? In my heart I feel a certain gratitude toward Brozik. He has released me."

"Now, since you are inevitably going, it would be pointless to continue refusing you what you want. That can only delay, not stop you. Better to cooperate, win back your goodwill, and in return have some influence on your actions. I will contact my colleagues. There should be no difficulty in getting a reversal of our decision."

Saxtorph sagged back in his chair. "Judas . . . priest."

"There are conditions," Markham told him. "If you are to be spared a long time idle here, prudent men must be spared nightmares about what grief you might bring on us all by some blunder. Excuse my blunt language. You are amateurs."

"Every explorer is an amateur. By definition."

"You are undermanned."

"I wouldn't say so. Captain; computerman; two pilots, who're also experienced rockjacks and planetsiders; quartermaster. Everybody competent in a slew of other specialties. And, this trip, two scientists, the prof and his student. What would anybody else *do*?"

"For one thing," Markham said crisply, "he would counsel proper caution and point out where this was not being exercised. He would keep official policy in your minds. The condition of your obtaining what you

need immediately is this. You shall take along a man who will have officer status—"

"Hey, wait a minute. I'm the skipper, my wife's the mate as well as the computerman, and the rest have shaken down into a damn good team. I don't aim to shake it back up again."

"You needn't," Markham assured him. "This man will be basically an observer and advisor. He should prove useful in several additional capacities. In the event of . . . disaster to the regular officers, he can take command, bring the ship back, and be an impartial witness at the inquiry."

"M-m-m." Saxtorph frowned, rubbed his chin, pondered. "Maybe. It'll be a long voyage, you know, about ninety days cooped up together, with God knows what at the end. Not that we expect anything more than interesting astronomical objects. Still, you're right, it is unpredictable. We're a close-knit crew, and the scientists seem to fit in well, but what about this stranger?"

"I refer you to my record," Markham replied. When Saxtorph drew a sharp breath, the Wunderlander added, "Yes, I am doubtless being selfish. However, my abilities in space are proven, and—in spite of everything, I share the dream."

5

In her youth, before she became a tramp, *Rover* was a naval transport, *UNS Ghost Dance*. She took men and matériel from their sources to bases around the Solar System, and brought some back for furlough or repair. A few times she went into combat mode. They were only a few. The kzinti hurled a sublight fleet out of Alpha Centauri at variable intervals, but years apart, since one way or another they always lost heavily in the sanguinary campaigns that followed. *Ghost Dance* would release her twin fighters to escort her on her rounds. Once they came under attack, and were the survivors.

Rover might now be less respectable, maybe even a

bit shabby, but was by no means a slattern. The Saxtorphs had obtained her in a postwar sale of surplus and outfitted her as well as their finances permitted. On the outside she remained a hundred-meter spheroid, its smoothness broken by airlocks, hatches, boat bays, instrument housings, communications boom, grapples, and micrometeoroid pocks that had given the metal a matte finish. Inboard, much more had changed. Automated as she was, she never needed more than a handful to man her; on a routine interplanetary flight she was quite capable of being her own crew. Most personnel space had therefore been converted for cargo stowage. Those people who did travel in her had more room and comfort than formerly. Instead of warcraft she carried two Prospector class boats, primarily meant for asteroids and the like but well able to maneuver in atmosphere and set down on a fair-sized planet. Other machinery was equally for peaceful, if occasionally rough use.

"But how did the Saxtorphs ever acquire a hyperdrive?" asked Laurinda Brozik. "I thought licensing was strict in the Solar System, too, and they don't seem to be terribly influential."

"They didn't tell you?" replied Kamehameha Ryan. "Bob loves to guffaw over that caper."

Her lashes fluttered downward. A tinge of pink crossed the alabaster skin. "I, I don't like to . . . pry—ask personal questions."

He patted her hand. "You're too sweet and considerate, Laurinda. Uh, okay to call you that? We are in for a long haul. I'm Kam."

The quartermaster was showing her around while *Rover* moved up the Alpha Centaurian gravity well until it would be safe to slip free of Einsteinian space. Her holds being vacant, the acceleration was several *g*, but the interior polarizer maintained weight at the half Earth normal to which healthy humans from every world can soon adapt. "You want the grand tour, not a hasty look-around like you got before, and who'd be a better guide than me?" Ryan had said. "I'm the guy who takes care of inboard operations, everything from dusting and

polishing, through mass trim and equipment service, on to cooking, which is the real art." He was a stocky man of medium height, starting to go plump, round-faced, dark-complexioned, his blue-black hair streaked with the earliest frost. A gaudy sleeveless shirt bulged above canary-yellow slacks and thong sandals.

"Well, I—well, thank you, Kam," Laurinda whispered.

"Thank *you*, my dear. Now this door I'd better not open for you. Behind it we keep chemical explosives for mining-type jobs. But you were asking about our hyperdrive, weren't you?"

"Well, after the war Bob and Dorcas—they met and got married during it, when he was in the navy and she was helping beef up the defenses at Ixa, with a sideline in translation—they worked for Solar Minerals, scouting the asteroids, and did well enough, commissions and bonuses and such, that at last they could make the down payment on this ship. She was going pretty cheap because nobody else wanted her. Who'd be so crazy as to compete with the big Belter companies? But you see, meanwhile they'd found the real treasure, a derelict hyperdrive craft. She wasn't UN property or anything, she was an experimental job a manufacturer had been testing. Unmanned; a monopole meteoroid passed close by and fouled up the electronics; she looped off on an eccentric orbit and was lost; the company went out of business. She'd become a legend of sorts, every search had failed, on which basis Dorcas figured out where she most likely was, and she and Bob went looking on their own time. As soon as they were ready they announced their discovery, claimed salvage rights, and installed the drive in this hull. Nobody had foreseen anything like that, and besides, they'd hired a smart lawyer. The rules have since been changed, of course, but we come under a grandfather clause. So here we've got the only completely independent starship in known space."

"It is very venturesome of you."

"Yeah, things often get precarious. Interstellar commerce hasn't yet developed regular trade routes, except

what government-owned lines monopolize. We have to take what we can get, and not all of it has been simple hauling of stuff from here to there. The last job turned out to be a lemon, and frankly, this charter is a god-send. Uh, don't quote me. I talk too much. Bob bears with me, but a tongue-lashing from Dorcas can take the skin off your soul."

"You and he are old friends, aren't you?"

"Since our teens. He came knocking his way around Earth to Hawaii, proved to be a good guy for a *haole*, I sort of introduced him to people and things, we had some grand times. Then he enlisted, had a real yeager of a war career, but you must know something about that. He looked me up afterward, when he and Dorcas were taking a second honeymoon, and later they offered me this berth."

"You had experience?"

"Yes, I'd gone spaceward too. Civilian. Interesting work, great pay, glamor to draw the girls, because not many flatlanders wanted to leave Earth when the next kzin attack might happen anytime."

"It seems so romantic," Laurinda murmured. "Superficially, at least, and to me."

"What do you mean, please?" Ryan asked, in the interest of drawing her out. Human females like men who will listen to them.

"Oh, that is—What have I done except study? And, well, research. I was born the year the Outsiders arrived at We Made It, but of course they were gone again long before I could meet them. In fact, I never saw a nonhuman in the flesh till I came to Centauri and visited Tigertown. You and your friends have been out, active, in the universe."

"I don't want to sound self-pitying," Ryan said, unable to quite avoid sounding smug, "but it's been mostly sitting inboard, then working our fingers off, frantic scrambles, shortages of everything, and moments of stark terror. A wise man once called adventure 'somebody else having a hell of a tough time ten light-years away.' "

She looked at him from her slightly greater elevation and touched his arm. "Lonely too. You must miss your family."

"I'm a bachelor type," Ryan answered, forbearing to mention the ex-wives. "Not that I don't appreciate you ladies, understand—"

At that instant, luck brought them upon Carita Fenger. She emerged from a cold locker with a hundred-liter keg of beer, intended for the saloon, on her back, held by a strap that her left hand gripped. High-tech tasks were apportioned among all five of *Rover's* people, housekeeping chores among the three crewmen. This boat pilot was a Jinxian. Her width came close to matching her short height, with limbs in proportion and bosom more so. Ancestry under Sirius had made her skin almost ebony, though the bobbed hair was no longer sun-bleached white but straw color. Broad nose, close-set brown eyes, big mouth somehow added up to an attractive face, perhaps because it generally looked cheerful. "Well, hi," she hailed. "What's going on here?"

Ryan and Laurinda halted. "I am showing our passenger around the ship," he said stiffly.

Carita cocked her head. "Are you, now? That isn't all you'd like to show her, I can see. Better get back to the galley, lad. You did promise us a first-meal feast." To the Crashlander: "He's a master chef when he puts his mind to it. Good in bed, too."

Laurinda dropped her gaze and colored. Ryan flushed likewise. "I'm sorry," he gobbled. "Pilot Fenger's okay, but she does sometimes forget her manners."

Carita's laugh rang. "I've not forgotten this nightwatch is your turn, Kam. I'll be waiting. Or shall I seduce Commissioner Markham—or Professor Tregennis?" To Laurinda: "Sorry, dear. I shouldn't have said that. Being coarse goes with the kind of life I've led. I'll try to do better. Don't be afraid of Kam. He's harmless as long as you don't encourage him."

She trudged off with her burden. To somebody born to Jinx gravity, the weight was trifling. Ryan struggled to find words. All at once Laurinda trilled laughter of

her own, then said fast, "I apologize. Your arrangements are your own business. Shall we continue for as long as you can spare the time?"

6

The database in *Rover* contained books as well as musical and video performances. Both the Saxtorphs spent a considerable amount of their leisure reading, she more than he. Their tastes differed enough that they had separate terminals in their cabin. He wanted his literature, like his food, plain and hearty; Dorcas ranged wider. Ever since hyperwave made transmission easy, she had been putting hundreds of writings by extrasolar dwellers into the discs, with the quixotic idea of eventually getting to know most of them.

The ship was a few days into hyperspace when she entered the saloon and found Tregennis. A couple of hours' workout in the gym, followed by a shower and change of coverall, left her aglow. The Plateaunian sat talking with Markham. That was unusual; the commissioner had kept rather to himself.

"Indeed the spectroscope, interferometer, the entire panoply of instruments reveals much," Tregennis was saying. "How else did Miss Brozik discover her star and learn of its uniqueness? But there is no substitute for a close look, and who would put a hyperdrive in an unmanned probe?"

"I know," Markham replied. "I was simply inquiring what data you already possess. That was never made clear to me. For example, does the star have planets?"

"It's too small and faint for us to establish that, at the distance from which we observed. Ah, I am surprised, sir. Were you so little interested that you didn't ask questions?"

"Why should he, when he was vetoing our mission?" Dorcas interjected. It brought her to their notice. Tregennis started to rise. "No, please stay seated." He looked so fragile. "No offense intended, Landholder

Markham. I'm afraid I expressed myself tactlessly, but it seemed obvious. After all, you were—are a busy man with countless claims on your attention."

"I understand, Mme. Saxtorph," the Wunderlander said stiffly. "You are correct. Feeling as I did, I took care to suppress my curiosity."

Tregennis shook his head in a bemused fashion. He doubtless wasn't very familiar with the twists and turns the human mind can take. Dorcas recalled that he had never been married, except to his science—though he did seem to regard Laurinda as a surrogate daughter.

The computerman sat down. "In fact," she said conciliatingly, "I still wonder why you felt you could be spared from your post for as long as we may be gone. You could have sent somebody else."

"Trustworthy persons are hard to find," Markham stated, "especially in the younger generation."

"I've gathered you don't approve of postwar developments on your planet." Dorcas glanced at Tregennis. "That's apropos the reason I hoped you would be here, Professor. I'm reading *The House on Crownsnest*—"

"What do you mean?" Markham interrupted. "Crownsnest is an area on top of Mount Lookitthat."

Dorcas curbed exasperation. Maybe he couldn't help being arrogant. "I understand it's considered the greatest novel ever written on Plateau," she said.

Tregennis nodded. "Many think so. I confess the language in it gets too strong for my taste."

"Well, the author is a Colonist, telling how things were before and during the revolution," Dorcas said in Markham's direction. "Oppression does not make people nice. The wonder is that Crew rule was overthrown almost bloodlessly."

"If you please," Tregennis responded, "we of the Crew families were not monsters. Many of us realized reform was overdue and worked for it. I sympathized myself, you know, although I did not take an active role. I do believe Nairn exaggerates the degree and extent of brutality under the old order."

"That's one thing I wanted to ask you about. His

book's full of people, places, events, practices that must be familiar to you but that nobody on any other planet ever heard of. Laurinda herself couldn't tell me what some passages refer to."

Tregennis smiled. "She has only been on Plateau as a student, and was born into a democracy. Why should she concern herself about old, unhappy, far-off things? Not that she is narrow, she comes from a cultured home, but she is young and has a whole universe opening before her."

Dorcas nodded. "A lucky generation, hers."

"Yes, indeed. Landholder Markham, I must disagree with views you have expressed. Taken as a whole, on every world the young are rising marvelously well to their opportunities—better, I fear, than their elders would have done."

"It makes a huge difference, being free," Dorcas said.

Markham sat bolt upright. "Free to do what?" he snapped. "To be vulgar, slovenly, ignorant, self-centered, materialistic, *common*? I have seen the degradation go on, year by year. You have stayed safe in your ivory tower, Professor. You, Mme. Saxtorph, operate in situations where a measure of discipline, sometimes old-fashioned self-sacrifice, is a condition of survival. But I have gotten out into the muck and tried to stem the tide of it."

"I heard you'd run for your new parliament, and I know you don't care for the popular modern styles," Dorcas answered dryly. She shrugged. "I often don't myself. But why should people not have what they want, if they can come by it honestly? Nobody forces you to join them. It seems you'd force them to do what pleases you. Well, that might not be what pleases me!"

Markham swallowed. His ears lay back. "I suspect our likes are not extremely dissimilar. You are a person of quality, a natural leader." Abruptly his voice quivered. He must be waging battle to keep his feelings under control. "In a healthy society, the superior person is recognized for what he or she is, and lesser ones

are happy to be guided, because they realize that not only they but generations to come will benefit. The leader is not interested in power or glory for their own sake. At most, they are means to an end, the end to which he gives his life, the organic evolution of the society toward its destiny, the full flowering of its soul. But we are replacing living *Gemeinschaft* with mechanical *Gesellschaft*. The cyborg civilization! It goes as crazy as a cyborg individual. The leading classes also lose their sense of responsibility. Those members who do not become openly corrupt turn into reckless megalomaniacs."

Dorcas paled, which was her body's way of showing anger. "I've seen that kind of thinking described in history books," she said. "I thought better of you, sir. For your information, my grandfather was a cyborg after an accident. Belters always believed it was as criminal to send convicts into the organ banks as any crime of theirs could be. He was the sanest man I've known. Nor have I noticed leaders of free folk doing much that is half as stupid or evil as what the master classes used to order. I'll make my own mistakes, thank you."

"You certainly will. You already have. I must speak plainly. Your husband's insistence on this expedition, against every dictate of sound judgment, merely because it suits him to go, is a perfect example of a leader who has ceased to be a shepherd. Or perhaps you yourself are, since you have aided and abetted him. You could have remembered how full of terrible unknowns space is. Belters are born to that understanding. He is a flatlander."

Dorcas whitened entirely. Her crest bristled. She stood up, fists on hips, to loom over Markham and say word by word: "That will do. We have endured your presence, that you pushed on us, in hopes you would prove to be housebroken. We have now listened to your ridiculous rantings because we believe in free speech where you do not, and in hopes you would soon finish. Instead, you have delivered an intolerable racist insult.

You will go to your cabin and remain there for twenty-four hours. Bread and water will be brought you."

Markham gaped. "What? Are you mad?"

"Furious, yes. As for sanity, I refrain from expressing an opinion about who may lack it." Dorcas consulted her watch. "You can walk to your cabin in about five minutes. Therefore, do not be seen outside it, except for visits to the head, until 1737 hours tomorrow. Go."

He half rose himself, sank back down, and exclaimed, "This is impossible! Professor Tregennis, I call you to witness."

"Yes," Dorcas said. "Please witness that he has received a direct order from me, who am second in command of the ship. Shall we call Captain Saxtorph to confirm it? You can be led off in irons, Markham. Better you obey. Go."

The commissioner clambered to his feet. He breathed hard. The others could smell his sweat. "Very well," he said tonelessly. "Of course I will file a complaint when we return. Meanwhile we shall minimize further conversation. Good day." He jerked a bow and marched off.

After a time in which only the multitudinous low murmurings of the vessel had utterance, Tregennis breathed, "Dear me. Was that not a . . . slightly excessive reaction?"

Dorcas sat down again. Her iciness was dissolving in calm. "Maybe. Bob would think so, though naturally he'd have backed me up. He's more good-natured than I am. I do not tolerate such language about him. This hasn't been the only incident."

"There is a certain prejudice against the Earth-born among the space-born. I understand it is quite widespread."

"It is, and it's not altogether without foundation—in a number of cases." Dorcas laughed. "I shared it, at the time Bob and I met. It caused some monumental quarrels the first couple of years, years when we could already have been married. I finally got rid of it and took to judging individuals on their merits."

"Forgive me, but are you not a little intolerant of those who have not had your enlightening experience?"

"Doubtless. However, between you and me, I welcomed the chance to show Markham who's boss here. I worried that if we have an emergency he could get insubordinate. That would be an invitation to disaster."

"He is a strange man," Tregennis mused. "His behavior, his talk, his past career, everything seems such a welter of contradictions. Or am I being naive?"

"Not really, unless I am too. Oh, people aren't self-consistent like the laws of mechanics—even quantum mechanics. But I do think we lack some key fact about Landholder Markham, and will never understand him till we have it." Dorcas made a gesture of dismissal. "Enough. Now may I do what I originally intended and quiz you about Plateau?"

7

While *Rover* was in hyperspace, all five of her gang stood mass detector watch, six hours a day for four days, fifth day off. It was unpopular duty, but they would have enjoyed still less letting the ship fly blind, risking an entry into a gravity well deep enough to throw her to whatever fate awaited vessels which did not steer clear. The daydream was becoming commonplace among their kind, that someday somebody would gain sufficient understanding of the psionics involved that the whole operation could be automated.

It wasn't torture, of course, once you had schooled yourself never to look into the Less Than Void which filled the single port necessarily left unshuttered. You learned how to keep an eye on the indicator globe while you exercised, read, watched a show, practiced a handicraft. On the infrequent occasions when it registered something, matters did get interesting.

"And I've decided I don't mind it in the least," said Juan Yoshii after Kamehameha Ryan had relieved him.

"Really?" asked Laurinda Brozik. She had met him below the flight deck by agreement.

He offered her his arm, a studied, awkward gesture not used in his native society. She smiled and took it. He was a young Sol-Belter. Unlike Dorcas Saxtorph, or most folk of his nation, he eschewed spectacular garb. Small, slim, with olive-skinned, almost girlish features, he did wear his hair in the crest, but it was cut short.

"I have just heard complaints about the monotony," Laurinda said.

"Monotony, or peacefulness?" he countered in his diffident fashion. "I chafed too. Then gradually I realized what an opportunity this is to be alone and think. Or compose."

"You don't sound like a rockjack," she said needlessly. It was what had originally attracted her to him.

He chuckled. "How are rockjacks supposed to sound? We have the rough, tough image, yes. Pilot the boat, find the ore, wrench it out, bring it home, and damn the meteoroids. Or the sun-flare or the fusion generator failure or anything else. But we are simply persons making a living. Quite a few of us look forward to a day when we can use different talents."

"What else would you like to do?"

His smile was stiff. He stared before him. "Prepare yourself to laugh."

"Oh, no." Her tone made naught of the eight centimeters by which she topped him. "How could I laugh at a man who handles the forces that I only measure?"

He flushed and had no answer. They walked on. The ship hummed around them. Bulkheads were brightly painted, pictures were hung on them and often changed, here and there were pots whose flowers Carita Fenger maintained, but nonetheless this was a barren environment. The two had a date in his cabin, where he would provide tea while they screened d'Auvergne's Fifth Chromophony. An appreciation of her work was one thing among others that they discovered they had in common.

"What is your hope?" Laurinda asked at last, low.

He gulped. "To be a poet."

"Why, how . . . how remarkable."

"Not that there's a living in it," he said hastily. "I'll need a groundside position. But I will anyway when I get too old for this berth—and am still fairly young by most standards." He drew breath. "In the centuries of spaceflight, how much true poetry has been written? Plenty of verse, but how much that makes your hair rise and you think yes, this is the real truth? It's as if we've been too busy to find the words for what we've been busy with. I want to try. I am trying, but know quite well I won't have a chance of succeeding with a single line till I've worked at it for another ten years or more."

"You're too modest, Juan. Genius flowers early oftener than not. I would like to see what you have done."

"No, I, I don't think it's that good. Maybe my efforts never will be. Not even equal to—well, actually minor stuff, but it does have the spirit—"

"Such as what?"

"Oh, ancient pieces, mostly, pre-space.

"*To follow knowledge like a sinking star,*

'Beyond the utmost bound of human thought.'—"

Yoshii cackled a laugh. "I'm really getting bookish, am I not? An easy trap to fall into. Spacemen have a lot of free time in between crises."

"You've put yours to good use," she said earnestly. "Is that poem you quoted from in the ship's database? I'd like to read it."

"I don't know, but I can recite it verbatim."

"That would be much better. Romantic—" Laurinda broke off. She turned her glance away.

He sensed her confusion and blurted in his own, "Please don't misunderstand me. I know—your customs, your mores—I mean to respect them. Completely."

She achieved a smile, though she could not yet look back his way. "Why, I'm not afraid of you." Unspoken: You're not unbearably frustrated. It's obvious that Carita is your mistress as well as Kam's. "You are a gentle-

man." And what we have coming to life between us is still small and frail, but already very sweet.

8

Rover re-entered normal space ten astronomical units from the destination star. That was unnecessarily distant for a mass less than a fourth of Sol's, but the Saxtorphs were more cautious than Markham admitted. Besides, the scientists wanted to begin with a long sweep as baseline for their preliminary observations, and it was their party now.

As soon as precise velocity figures were available, Dorcas computed the vectors. The star was hurtling at well over a thousand kilometers per second with respect to galactic center. That meant the ship needed considerable Δv to get down to interplanetary speeds and into the equatorial plane where any attendant bodies were likeliest to be. That boost phase must also serve those initial requirements of the astronomers. Course and thrust could be adjusted as data came in and plans for the future were developed.

The star's motion meant, too, that it was escaping the galaxy, bound for the gulfs beyond. Presumably an encounter with one or more larger bodies had cast it from the region where it formed. A question the expedition hoped to get answered, however incompletely, was where that might have happened—and when.

Except for Dorcas, who worked with Tregennis to process the data that Laurinda mostly gathered, the crew had little to do but housekeeping. Occasionally someone was asked to lend a hand with some task of the research.

Going off watch, Carita Fenger stopped by the saloon. A large viewscreen there kept the image of the sun at the cross-haired center. Else nobody could have identified it. It was waxing as the ship drove inward but thus far remained a dim dull-red point, outshone by stars light-years away. The undertone of power through

the ship was like a whisper of that which surged within, around, among them, nuclear fires, rage of radiation, millennial turmoil of matter, births and funeral pyres and ashes and rebirths, the universe forever in travail. Like most spacefarers, Carita could lose herself, hour upon hour, in the contemplation of it.

She halted. Markham sat alone, looking. His face was haggard.

"Well, hi," she said tentatively.

Markham gave her a glance. "How do you do, Pilot Fenger." The words came flat.

She plumped herself down in the chair beside him. "Quite a sight, eh?"

He nodded, his gaze back on the screen.

"A trite thing to say," she persisted. "But I suspect Juan's wrong. He hopes to find words grand enough. I suspect it can't be done."

"I was not aware Pilot Yoshii had such interests," said Markham without unbending.

"Nah, you wouldn't be. You've been about as outgoing as a black hole. What's between you and Dorcas? You seem to be off speaking terms with her."

"If you please, I am not in the mood for gossip." Markham started to rise, to leave.

Carita took hold of his arm. It was a gentle grip, but he could easier have broken free of a salvage grapple. "Wait a minute," she said. "I've been halfway on the alert for a chance to talk with you. Who does any more, except 'Pass the salt' at mess, that sort of thing? How lonesome you must be."

He refrained from ineffectual resistance, continued to stare before him, and clipped, "Thank you for your concern, but I manage. Kindly let go."

"Look," she said, "we're supposed to be shipmates. It's a hell of an exciting adventure—Christ, we're the first, the very first, in all this weird wonder—but it's cold out, too, and doesn't care an atom's worth about human beings. I keep thinking how awful it must be, cut off from any friendship the way you are. Not that you've exactly encouraged us, but we could try harder."

Now he did regard her. "Are you inviting me to your bed?" he asked in the same tone as before.

Slightly taken aback, she recovered, smiled, and replied, "No, I wasn't, but if it'll make you feel better we can have a go at it."

"Or make you feel better? I am not too isolated to have noticed that lately Pilot Yoshii has ceased visiting your cabin. Is Quartermaster Ryan insufficient?"

Carita's face went sulfur black. She dragged her fingers from him. "My mistake," she said. "The rest were right about you. Okay, you can take off."

"With pleasure." He stalked out.

She mumbled an oath, drew forth a cigar, lit and blew fumes that ran the ventilators and air renewers up to capacity. Calm returned after a while. She laughed ruefully. Ryan had told her more than once that she was too soft-hearted; and he was a man prone to fits of improvident generosity.

She was about to go when Saxtorph's voice boomed from the intercom: "Attention, please. Got an announcement here that I'm sure will interest everybody.

"We'll hold a conference in a few days, when more information is in. Then you can ask whatever questions you want. Meanwhile, I repeat my order, do not pester the science team. They're working around the clock and don't need distractions.

"However, Arthur Tregennis has given me a quick rundown on what's been learned so far, to pass on to you. Here it is, in my layman's language. Don't blame him for any garbling.

"They have a full analysis of the sun's composition, along with other characteristics. That wasn't too easy. For one thing, it's so cool that its peak emission frequency is in the radio band. Because the absorption and re-emission of the interstellar medium in between isn't properly known, we *had* to come here to get decent readings.

"They bear out what the prof and Laurinda thought. This sun isn't just metal-poor, it's metal-impoverished. No trace of any element heavier than iron, and little of

that. Yes, you've all heard as how it must be very old, and has only stayed on the main sequence this long because it's such a feeble dwarf. But now they have a better idea of just how long 'this' has been.

"Estimated age, fifteen billion years. Our star is damn near as old as the universe.

"It probably got slung out of its parent galaxy early on. In that many years you can cover a lot of kilometers. We're lucky that we—meaning the human species—we're alive while it's in our neighborhood.

"And . . . in the teeth of expectations, it's got planets. Already the instruments are finding signs of oddities in them, no two alike, nothing we could have foreseen. Well, we'll be taking a close look. Stand by. Over."

Carita sprang to her feet and cheered.

9

Once when they were young bucks, chance-met, beachcombing together in the Islands, Kam Ryan and Bob Saxtorph acquired a beat-up rowboat, cat-rigged it after a fashion, stowed some food and plenty of beer aboard, and set forth on a shakedown cruise across Kaulakahi Channel. Short runs off Waimea had gone reasonably well, but they wanted to be sure of the seaworthiness before making it a lure for girls. They figured they could reach Niihau in 12 or 15 hours, land if possible, rest up in any case, and come back. They didn't have the price of an outboard, but in a pinch they could row.

To avoid coping with well-intentioned busybodies, they started after dark. By that time sufficient beer had gone down that they forgot about tuning in a weather report before leaving their tent—at the verge of kona season.

It was a beautiful night, half a moon aloft and so many stars they could imagine they were in space. Wind lulled, seas whooshed, rigging creaked, the boat

rocked forward and presently a couple of dolphins appeared, playing alongside for hours, a marvel that made even Kam sit silent in wonder. Then toward dawn, the goal a vague darkness ahead, clouds boiled out of the west, wind sharpened and shrilled, suddenly rain slanted like a flight of spears and through murk the mariners heard waves rumble against rocks.

It wasn't much of a storm, really, but ample to deal with *Wahine*. Seams opened, letting in water to join that which dashed over the gunwales. Sail first reefed, soon struck, stays nonetheless gave way and the mast went. It would have capsized the hull had Bob not managed to heave it free. Thereafter he had the oars, keeping bow on to the waves, while Kam bailed. A couple of years older, and no weakling, the Hawaiian couldn't have rowed that long at a stretch. Eventually he did his share and a bit at the rudder, when somehow he worked the craft through a gap between two reefs which roared murder at them. They hit coral a while later, but close enough to shore that they could swim, never sure who saved the life of who in the surf. Collapsing behind a bush, they slept the weather out.

Afterward they limped off till they found a road and hitched a ride. They'd been blown back to Kauai. Side by side, they stood on the carpet before a Coast Guard officer and endured what they must.

Next day in their tent, Kam said, unwontedly solemn—the vast solemnity of youth—"Bob, listen. You've been my *hoa* since we met, you became my *hoaloha*, but what we've been through, what you did, makes you a *hoapili*."

"Aw, wasn't more'n I had to, and you did just as much," mumbled the other, embarrassed. "If you mean what I suppose you do, okay, I'll call you *kammerat*, and let's get on with whatever we're going to do."

"How about this? I've got folks on the Big Island. A tiny little settlement tucked away where nobody ever comes. Beautiful country, mountains and woods. People still live in the old kanaka style. How'd you like that?"

"Um-m, how old a style?"

Kam was relieved at being enabled to laugh. "You won't eat long pig! Everybody knows English, though they use Hawaiian for choice, and never fear, you can watch the Chimp Show. But it's a great, relaxed, cheerful life—you've got to experience the girls to believe—the families don't talk about it much when they go outside, or invite *haolena* in, because tourists would ruin it—but you'll be welcome, I guarantee you. How about it?"

The month that followed lived up to his promises, and then some.

Recollections of it flew unbidden across the years as Ryan worked in the galley. Everybody else was in the gym, where chairs and projection equipment had been brought, for the briefing the astronomers would give. *Rover* boosted on automatic; her instruments showed nothing ahead that she couldn't handle by herself for the next million kilometers. The quartermaster could have joined the group, but he wanted to make a victory feast ready. Before long, they'd be too busy to appreciate his art.

He did have a screen above the counter, monitoring the assembly.

Tregennis and Laurinda stood facing their audience. The Plateaunian said, with joy alive beneath the dry words:

"It is a matter of semantics whether we call this a first- or a second-generation system. Hydrogen and helium are overwhelmingly abundant, in proportions consistent with condensation shortly after the Big Bang—about which, not so incidentally, we may learn something more than hitherto. However, oxygen, nitrogen, carbon, silicon, and neon are present in significant quantities; magnesium and iron are not insignificant; other elements early in the periodic table are detectable. There has naturally been a concentration of heavier atoms in the planets, especially the inner ones, as gases selectively escaped. They are not mere balls of water ice.

"It seems clear, therefore, that this system formed out of a cloud which had been enriched by mass loss from older stars in their red giant phase. A few supernovae may have contributed too, but any elements heavier than iron which they may have supplied are so scant that we will only find them by mass spectrography of samples from the solid bodies. They may well be nonexistent. Those older stars must have come into being as soon after the Beginning as was physically possible, in a proto-galaxy not too far then from the matter which was to become ours, but now surely quite distant from us."

"As we dared hope," said the Crashlander. Tears glimmered in her eyes like dew on rose petals.

"Oh, good for you!" called Yoshii.

"A relic—hell, finding God's fingerprints," Carita said, and clapped a hand to her mouth. Ryan grinned. Nobody else noticed.

"How many planets?" asked Saxtorph.

"Five," Tregennis replied.

"Hm. Isn't that kind of few, even for a dwarf? Are you sure?"

"Yes. We would have found anything of a size much less than what you would call a planet's."

"Especially since the Bode function is small, as you'd expect," Dorcas added. Having worked with the astronomers, she scarcely needed this session. "The planets huddle close in. We haven't found an Oort cloud either. No comets at all, we think."

"Outer bodies may well have been lost in the collision that sent this star into exile," Laurinda said. "And in fifteen billion years, any comets that were left got . . . used up."

"There probably was a sixth planet until some unknown date in the past," Tregennis stated. "We have indications of asteroids extremely close to the sun. Gravitational radiation—no, it must chiefly have been friction with the interstellar medium that caused a parent body to spiral in until it passed the Roche limit and was disrupted."

"Hey, wait," Saxtorph said. "Dorcas talks of a Bode function. That implies the surviving planets are about where theory says they ought to be. How'd they avoid orbital decay?"

Tregennis smiled. "That's a good question."

Saxtorph laughed. "Shucks, you sound like I was back in the Academy."

"Well, at this stage any answers are hypothetical, but consider. In the course of its long journey, quite probably through more galaxies than ours, the system must sometimes have crossed nebular regions where matter was comparatively dense. Gravitation would draw the gas and dust in, make it thickest close to the sun, until the sun swallowed it altogether. As a matter of fact, the planetary orbits have very small eccentricities—friction has a circularizing effect—and their distances from the primary conform only roughly to the theoretical distribution." Tregennis paused. "A further anomaly we cannot explain, though it may be related. We have found—marginally; we think we have found—molecules of water and OH radicals among the asteroids, almost like a ring around the sun." He spread his hands. "Well, I won't live to see every riddle we may come upon solved."

He had fought to get here, Ryan remembered.

"Let's hear about those planets," Carita said impatiently. Her job would include any landings. "Uh, have you got names for them? One, Two, Three might cause mixups when we're in a hurry."

"I've suggested using Latin ordinals," Laurinda answered. She sounded almost apologetic.

"Prima, Secunda, Tertia, Quarta, Quinta," Dorcas supplied. "Top-flight idea. I hope it becomes the standard for explorers." Laurinda flushed.

"I have agreed," Tregennis said. "The philologists can bestow official names later, or whoever is to be in charge of such things. Let us give you a *précis* of what we have learned to date."

He consulted a notator in his hand. "Prima," he recited. "Mean orbital radius, approximately 0.4 A.U. Diameter, approximately 16,000 kilometers. Since it

has no satellite, the mass is still uncertain, but irradiation is such that it cannot be icy. We presume the material is largely silicate, which—allowing for self-compression—gives a mass on the order of Earth's. No signs of air.

"Secunda, orbiting at 0.7 A. U., resembles Prima, but is slightly larger and does have a thin atmosphere, comparable to Mars'. It has a moon as well. Remarkably, the moon has a higher albedo than expected, a yellowish hue. The period tells us the mass, of course, which reinforces our guess about Prima.

"Tertia is almost exactly one A.U. out. It is a super-terrestrial, mass of five Earths, as confirmed by four moons, also yellowish. A somewhat denser atmosphere than Secunda's; we have confirmed the presence of nitrogen and traces of oxygen."

"What?" broke from Saxtorph. "You mean it might have life?"

Laurinda shivered a bit. "The water is forever frozen," she told him. "Carbon dioxide must often freeze. We don't know how there can be any measurable amount of free oxygen. But there is."

Tregennis cleared his throat. "Quarta," he said. "A gas giant at 1.5 A.U., mass 230 Earths, as established by ten moons detected thus far. Surprisingly, no rings. Hydrogen and helium, presumably surrounding a vast ice shell which covers a silicate core with some iron. It seems to radiate weakly in the radio frequencies, indicating a magnetic field, though the radio background of the sun is such that at this distance we can't be sure. We plan a flyby on our way in. Quarta will be basic to understanding the dynamics of the system. It is its equivalent of Jupiter."

"Otherwise we have only detected radio from Secunda," Laurinda related, "but it is unmistakable, cannot be of stellar origin. It is really curious—intermittent, seemingly modulated, unless that is an artifact of our skimpy data." She smiled. "How lovely if intelligent beings are transmitting."

Markham stirred. He had put his chair behind the row of the rest. "Are you serious?" he nearly shouted.

Surprised looks went his way. "Oh, no," Laurinda said. "Just a daydream. We'll find out what is actually causing it when we get there."

"Well, Quinta remains," Tregennis continued, "in several respects, the most amazing object of all. Mass 103 Earths—seven moons found—at 2.8 A.U. It does have a well-developed ring system. Hydrogen-helium atmosphere, but with clear spectra of methane, ammonia, and . . . water vapor. Water in huge quantities. Turbulence, and a measured temperature far above expectations. Something peculiar has happened.

"Are there any immediate questions? If not, Laurinda and Dorcas have prepared graphics—charts, diagrams, tables, pictures—which we would like to show. Please feel free to inquire, or to propose ideas. Don't be bashful. You are all intelligent people with a good understanding of basic science. Any of you may get an insight which we specialists have missed."

Markham rose. "Excuse me," he said.

"Huh?" asked Saxtorph, amiably enough. "You want to go now when this is really getting interesting?"

"I do not expect I can make a contribution," Markham hesitated. "I am a little indisposed. Best I lie down for a while. Do not worry. I will soon be well. Carry on." He sketched a bow and departed.

"What do you know, he is human," Carita said.

"We ought to be kinder to him than we have been, poor man," Laurinda murmured.

"He hasn't given us much of a chance, has he?" replied Yoshii.

"Stow that," Saxtorph ordered. "No backbiting."

"Yes," added Dorcas, "let's proceed with the libretto."

Eagerness made Tregennis tremble as he obliged.

In his galley, Ryan frowned. Something didn't feel quite right. While he followed the session he continued slicing the mahimahi he had brought frozen from Earth, but his mind was no longer entirely on either.

Time passed. It became clear that the Quarta ap-

proach was going to be an intellectual orgy, the more so because Quinta happened to be near inferior conjunction and thus a lot of information about that planet would be arriving too. Ryan wiped hands on apron, left his preparations, and stumped up toward the flight deck.

He met Markham coming back. They halted and regarded each other. The companionway thrummed around them. "Hello, there," the quartermaster said slowly. "I thought you were in your cabin."

Markham stiffened. "I am on my way, if it is any of your business."

"Long way 'round."

"It . . . occurred to me to check certain stations. This is an old ship, refitted. Frankly, Captain Saxtorph relies too much on his machinery."

"What sort of thing did you want to check on?"

"Who are you to ask?" Markham flung. "You are the quartermaster."

"And you are the passenger." Ryan's bulk blocked the stairs. "I wouldn't be in this crew if I didn't have a pretty fair idea of how all the equipment works. I'm responsible for maintaining a lot of it."

"I have commanded spacecraft."

"Then you know each system keeps its own record." Ryan's smile approximated a leer, or a snarl. "Save the skipper a bunch of data retrievals. Where were you and what were you doing?"

Markham stood silent while the ship drove onward. At length: "I should, I shall report directly to the captain. But to avoid rumors, I tell you first. Listen well and do not distort what I say if you are able not to. I beamed a radio signal on a standard band at Secunda. It is against the possibility—the very remote possibility, Mlle. Brozik assured us—that sentient beings are present. Natives, Outsiders, who knows? In the interest of peaceful contact, we must provide evidence that we did not try to sneak in on them. Not that it is likely they exist, but—this is the sort of contingency I am here for.

Saxtorph and I can dispute it later if he wishes. I have presented him with a *fait accompli*. Now let me by."

Ryan stood aside. Markham passed downward. Ryan stared after him till he was gone from sight, then went back to his galley.

10

Quarta fell astern as *Rover* moved on sunward. In the boat called *Fido*, Juan Yoshii swung around the giant planet and accelerated to overtake his ship. Vectors programmed, he could relax, look out the ports, seek to sort the jumbled marvels in his mind. Most had gone directly from instruments to the astronomers; he was carrying back certain observations taken farside. A couple of times there had been opportunity for Laurinda Brozik to tell him briefly about the latest interpretation, but he had been too busy on his flit to think much beyond the piloting.

Stars thronged, the Milky Way torrented, a sky little different from the skies he remembered. Less than 30 light-years' travel—a mite's leap in the galaxy. Clearly alien was the sun ahead. Tiny but perceptible, its ember of a disc was slow to dazzle his eyes, yet already cast sufficient light for him to see things by.

An outer moon drifted across vision. This was his last close passage, and instruments worked greedily. Clicks and whirrs awoke beneath the susurrus of air through the hull. Yoshii pointed his personal camera; photography was an enthusiasm of his. The globe glimmered wan red under its sun. It was mainly ice, and smooth; any cracks and craters had slumped in the course of gigayears. The surface was lighter than it might have been and mottled with yellow spots. Ore deposits? The same material that tinted most airless bodies here? Tregennis was puzzled. You got dark spots in Solar-type systems. They were due to photolysis of frozen methane. Of course, this sun was so feeble. . . .

It nonetheless illuminated the planet aft. Quarta's

hue was pale rose, overlaid with silvery streaks that were ice clouds: crystals of carbon dioxide, ammonia, in the upper levels methane. No twists, no vortices, no sign of any Jovian storminess marred the serenity. Though the disc was visibly flattened, it rotated slowly, taking more than 40 hours. Tidal forces through eons had worn down even the spin of this huge mass. They had likewise dispersed whatever rings it once had, and surely drawn away moons. The core possessed a magnetic field, slight, noticeable only because it extended so far into space that it snatched radio waves out of incoming cosmic radiation—remanent magnetism, locked into iron as that core froze. For gravitational energy release had long since reached its end point; and long, long before then, K-40 and whatever other few radionuclei were once on hand had guttered away beyond measurement. The ice sheath went upward in tranquil allotropic layers to a virtually featureless surface and an enormous, quietly circulating atmosphere of starlike composition. Quarta had reached Nirvana.

It fell ever farther behind. *Fido* closed in on *Rover*. The ship swelled until she might have been a planet herself. Instructions swept back and forth, electronic, occasionally verbal. A boat bay opened its canopy. Yoshii maneuvered through and docked. The canopy closed, shutting off heaven. Air hissed back in from the recovery tanks. A bulb flashed green. Yoshii unharnessed, operated the lock, crawled forth, and walked under the steady weight granted him by the ship's polarizer, into her starboard reception room.

Laurinda waited.

Yoshii stopped. She was alone. White hair tumbled past delicate features to brush the dress, new to him, that hugged her slenderness. She reached out. Her eyes glowed. "W-welcome back, Juan," she whispered.

"Why, uh, thanks, thank you. You're the . . . committee?"

She smiled, dropped her glance, became briefly the color of the world he had rounded. "Kam met Carita. As for you, Dorcas—Mate Saxtorph suggested—"

He took her hands. They felt reed-thin and silk-soft. "How nice of her. And the rest. I've data discs for you."

"They'll keep. We have more work than we can handle. Observations of Quinta were, have been incredibly fruitful." Ardor pulsed in her voice. The outermost planet was a safe subject. "We think we can guess its nature, but of course there's no end of details we don't understand, and we could be entirely wrong—"

"Good for you," he said, delighted by her delight. "I missed out on that, of course." Transmissions to him, including hers, had dealt with the Quartan system exclusively; any bit of information about it might perhaps save his life. "Tell me."

"Oh, it's violent, multi-colored, with spots like Jupiter's—one bigger than the Red—and—The surface is liquid water. It's Arctic-like; we imagine continent-sized ice floes clashing together."

"But warmer than Quarta! Why?"

"We suppose a large satellite crashed, a fraction of a million years ago. Debris formed the rings. The main mass released enough heat to melt the upper part of the planetary shell, and, and we'll need years, science will, to learn what else has happened."

He stood for an instant in awe, less of the event than of the time-scale. That moon must have been close to start with, but still it had taken the casual orbital erosion of . . . almost a universe's lifespan so far—how many passages through nebulae, galaxies, the near-ultimate vacuum of intergalactic space?—to bring it down. *What is man, that thou art mindful of him—?*

What is man, that he should waste the little span which is his?

"That's wonderful," he said, "but—we—"

Impulsively, he embraced her. Astoundingly, she responded.

Between laughter and tears she said in his ear, "Come, let's go. Kam's spread a feast for the two of us in my cabin."

Set beside that, the cosmos was trivial.

Saxtorph's voice crackled from the intercom: "Now

hear this. Now hear this. We've just received a message from what claims to be a kzin warship. They're demanding we make rendezvous with them. Keep calm but think hard. We'll meet in the gym in an hour, 1530, and consider this together."

11

Standing with back to bulkhead, the captain let silence stretch, beneath the pulsebeat and whispers of the ship, while he scanned the faces of those seated before him. Dorcas, her Athene countenance frozen into expressionlessness; Kam Ryan's full lips quirked a bit upward, defiantly cheerful; Carita Fenger a scowl; Juan Yoshii and Laurinda Brozik unable to keep from glancing at each other, hand gripping hand; Arthur Tregennis, who seemed almost as concerned about the girl; Ulf Markham, well apart from the rest, masked in haughtiness—Ulf *Reichstein* Markham, if you please. . . . The air renewal cycle was at its daily point of ozone injection. That tang smelled like fear.

Which must not be let out of its cage. Saxtorph cleared his throat.

"Okay, let's get straight to business," he said. "You must've noticed a quiver in the interior g-field and change in engine sound. You're right, we altered acceleration. *Rover* will meet the foreign vessel, with velocities matched, in about 35 hours. It could be sooner, but Dorcas told them we weren't sure our hull could take that much stress. What we wanted, naturally, was as much time beforehand as possible."

"Why don't we cut and run?" Carita asked.

Saxtorph shrugged. "Whether or not we can outrun them, we for sure can't escape the stuff they can throw, now that they've locked onto us. If they really are kzinti navy, they'll never let us get out where we can go hyperspatial. They may be lying, but Dorcas and I don't propose to take the chance."

"I presume evasion tactics are unfeasible," said Tregennis in his most academic voice.

"Correct. We could stop the engine, switch off the generator, and orbit free, with batteries supplying the life support systems, but they'd have no trouble computing our path. As soon as they came halfway close, they'd catch us with a radar sweep.

"From what data we have on them, I believe they were searching for some time before they acquired us, probably with amplified optics. That's assuming they were in orbit around Secunda when they first learned of our arrival. The assumption is consistent with what would be a reasonable search curve for them and with the fact that there are modulated radio bursts out of that planet—transmissions to and from their base."

Nobody before had seen Yoshii snarl. "And how did they learn about us?" he demanded.

Looks went to Markham. He gave them back. "Yes, undoubtedly through me," he said. Strength rang in the words. "You all know I took it upon myself to beam a signal at Secunda—in my capacity as this expedition's officer of the government. The result has surprised me too, but I acknowledge no need to apologize. If we, approaching a kzin base unbeknownst, had suddenly become manifest to their detectors, they would most likely have blown us out of existence."

Ryan nodded. "Without stopping to ask questions," he supplied. "Yeah, that'd be kzin style. If they are. How're you so sure?"

"I think we can take it for granted," Dorcas said. "Who else would have reason to call themselves kzinti?"

"Who else would want to?" Carita growled.

"Save the cuss words for later," Saxtorph counselled. "We're in too much of a pickle for luxuries. I might add that although the vocal transmission was through a translator, the phrasing, the responses to us, everything was pure kzin. They are here—on the far side of human space from their own. You realize what this means, don't you, folks? The kzinti have gotten the hyperdrive."

That conclusion had indeed become clear to every-

one, but Laurinda asked, "How could they?" as if in pain.

Yoshii grimaced. "Once you know something can be done, you're halfway to doing it yourself," he told her.

"I know," she answered. "But I had the, the impression they aren't quite as clever at engineering as humans, even if they did invent the gravity polarizer. And, and wouldn't we have known?"

"Collecting intelligence in kzin space isn't exactly easy," Saxtorph explained. "Anyhow, they may have done the R and D on some planet we aren't aware of. I'll grant you, I'm surprised myself that they've been this quick. Well, they were." His grin was lopsided. "Once I heard about an epitaph on an old New England tombstone. 'I expected this, but not so soon.'"

"Why have they established themselves here?" Tregennis wondered. "As you observed, it is a long journey for them, especially if they went around human space in order to avoid any chance that their possession of the hyperdrive would be discovered. True, this system is uniquely interesting, but I didn't think kzin civilization gave scientific research as high a value as ours does."

"That's a good question," Saxtorph said.

His gallows humor drew a chuckle from none but Ryan. Dorcas uttered the thought in every mind: "They won't let us go home to tell about them if they can help it."

"Which is why we are being nice and meeting them as they request," Saxtorph added. "It gives them an alternative to putting a nuke on our track."

Markham folded his arms and stated, "I hope you people have the wit to be glad, at last, that I came along. They will understand that I am authorized to negotiate with them. They will likewise understand that my disappearance would in due course cause a second expedition to come, with armed escort, as the loss of an entirely private group might not."

"Could be," Saxtorph said. "However, I can think of several ways to fake a natural disaster for us."

"Such as?"

"Well, for instance, giving us a lethal dose of radiation, then sending the corpses back with the ship gimmicked to seem this was an accident. The kzin pilot could return on an accompanying vessel after ours left hyperspace."

"What would the log show?"

"What the 'last survivor' was tortured into entering."

"Nonsense. You have been watching too many spy dramas."

"I disagree. Besides, that was just one of the notions that occurred to Dorcas and me. The kzinti might be more inventive yet."

"We have decided not to rely exclusively on their sweet nature," the mate declared. "Listen carefully."

"We can launch the boats without them detecting it, if we act soon. They'll float free while *Rover* proceeds to rendezvous. When she's a suitable distance off, nobody looking for any action in this volume of space, they'll scramble."

Carita smacked fist in palm. "Hey, terrific!" she cried.

Markham sounded appalled: "Have you gone crazy? How will you survive, let alone return, in two little interplanetary flitters?"

"They're more than that," Saxtorph reminded. "They're rugged and maneuverable and full to the scuppers with delta v. In either of 'em I'd undertake to outrace or dodge a tracking missile, and make it tough or impossible to hold a laser beam on her long enough to do much damage. Air and water recyclers are in full working order and rations for one man-year are stowed aboard."

"I, I ate some," Yoshii stammered. "Carita must have too."

"I've already replaced it," Ryan informed them.

"Good thinking!" Saxtorph exclaimed. "Did you expect this tactic?"

"Oh, general principles. Take care of your belly and your belly will take care of you."

"Stop that schoolboy chatter," Markham snapped. "What in the cosmos can you hope to do but antagonize the kzinti?"

"How do you tell an antagonized kzin from an unantagonized one?" Saxtorph retorted. "I am dead serious. Nobody has to follow me who doesn't want to."

"I certainly do not. Someone has to stay and . . . try to repair the harm your lunacy will have done."

"I figured you would. But I supposed you, of all people, would have a better hold on kzin psychology than you're showing. You ought to know they don't resent an opponent giving them a proper fight. Fighting's their nature. Whoever surrenders becomes no more than a captured animal in their eyes. Dorcas and I aim to put some high cards in your hand before you sit down at their poker table. A spacecraft on the loose is a weapon. The drive, or the sheer kinetic energy, can wreck things quite as thoroughly as the average nuke. Come worst to worst, we might smash a boat into their base at several thousand k.p.h. The other boat might take out their ship and leave them stranded; I've a hunch they've kept just a single hyperdrive vessel, as scarce as those must still be among them. Yah, going out like that would be a sight better than going into the stewpot. Kzinti like long pig."

Yoshii brightened. He and Laurinda exchanged a wonder-smitten look. Carita whooped. Tregennis smiled faintly. Ryan went oddly, abruptly thoughtful.

Markham gnawed his lip a moment, then straightened in his chair and rapped, "Very well. I do not approve, and I ask the crew to refrain from this foolishness of yours, but I cannot stop you. Therefore I must factor your action into my calculations. What terms shall I try to get for us?"

"Freedom to leave, of course," Dorcas responded. "Let *Rover* retreat to hyperspacing distance and wait, while the kzinti withdraw too far to intercept our boats. We can verify that on instruments before we come near. We'll convey any message they want, or even a delegate."

"There could be a delegation on board, waiting," Ryan warned.

Tregennis stirred. "I will remain behind," he said.

Tears sprang into Laurinda's eyes. "Oh, no!" she pleaded.

He smiled again, at her. "I am too old to go blatting around space like that. I would merely be a burden, and quite likely die on your hands. Not only will I be more comfortable here, I will be an extra witness to the bona fides of the kzinti. Landholder Markham alone could not keep track of everything they might stealthily do."

"It will show them there are two reasonable human beings in this outfit," the Wunderlander said. "That might be marginally helpful to me. Anyone else?"

"Speaking," Ryan answered.

"Huh?" broke from Saxtorph. "Hey, Kam, no. Whatever for?"

"For this," the quartermaster said calmly. "Haven't you thought of it yourself? The boats will be on the move, or holed up someplace unknown to the kzinti. They can only be reached by broadcast. Planar broadcast, maybe, but still the signal's bound to be down in the milliwatts or microwatts when it reaches your receivers—with the sun's radio background to buck. Nothing but voice transmission will carry worth diddly. Given a little time to record how the humans talk who were left behind, the kzinti can write a computer program to fake it. 'Sure, come on back, fellows, all is forgiven and they've left a case of champagne for us to celebrate with.' How're you going to know that's for real?"

Dorcas frowned. "We did consider it," she told him. "We'll use a secret password."

"Which a telepath of theirs can fish right out of a human skull, maybe given a spot of torture to unsettle the brain first. Nope, I know a trick worth two of that. How well do you remember your Hawaiian, Bob? You picked up a fair amount while we were in the village." Ryan laughed. "That worked on the girls like butter on a toboggan slope."

Saxtorph was a long while silent before he answered:

"I think, if I practiced for a few days, I think . . . enough of it . . . would come back to me."

Ryan nodded. "The kzinti have programs for the important human languages in their translators, but I doubt Hawaiian is included. Or Danish."

Yoshii swallowed. "You'd certify everything is kosher?" he mumbled. "But what if—well—"

"If the kzinti aren't stupid, they won't try threatening or torturing me into feeding you a lie," Ryan responded. "How'd they savvy what I was saying? I assure you, it wouldn't be complimentary to them."

"A telepath would know."

Ryan shrugged. "He'd know I was not going to be their Judas goat, no matter what they did. Therefore they won't do it."

Saxtorph's right hand half reached out. "Kam, old son—" he croaked. The hand dropped.

Dorcas rose and confronted the rest, side by side with her husband. "I'm sorry, but time is rationed for us and you must decide at once," she said. "If you think you'd better stay, then do. We won't consider you a coward or anything. You may be right. We can't be sure at this stage. All we are certain of is that we don't have time for debate. Who's going?"

Hands went up, Carita's, Yoshii's, and after an instant Laurinda's.

"Okay," Dorcas continued. "Now we're not about to put our bets on a single number. The boats will go separate ways. Which ways, we'll decide by tight beam once we're alone in space. You understand, Kam, Arthur, Landholder Markham. What you don't know, a telepath or a torturer can't get out of you. Bob and I have already considered the distribution. Carita and Juan will take *Fido*. We thought Kam would ride with them, but evidently not. Laurinda, you'll be with Bob and me in *Shep*."

"Wait a minute!" Yoshii protested. The girl brought fingertips to open mouth.

"Sorry, my dears," Dorcas said. "It's a matter of practicality, as nearly as we could estimate on short

notice. Not that we imagine you two would play Romeo and Juliet to the neglect of your duties. However, Juan and Carita are our professional pilots, rockjacks, planet-side prospectors. Together they make our strongest possible team. They can pull stunts Bob and I never could. We need that potential, don't we? Bob and I are no slouches, but we do our best work in tandem. To supply some of what we lack as compared to Juan and Carita, Laurinda has knowledge, including knowledge of how to use instruments we plan to pack along. Don't forget, more is involved than us. The whole human race needs to know what the kzinti are up to. We must maximize our chances of getting the news home. Agreed?"

Yoshii clenched his free hand into a fist, stared at it, raised his head, and answered, "Aye. And you can take better care of her."

The Crashlander flushed. "I'm no piece of porcelain!" Immediately contrite, she stroked the Belter's cheek while she asked unevenly, "How soon do we leave?"

Dorcas smiled and made a gesture of blessing. "Let's say an hour. We'll need that much to stow gear. You two can have most of it to yourselves."

12

The kzin warship was comparatively small, Prowling Hunter class, but not the less terrifying a sight. Weapon pods, boat bays, sensor booms, control domes studded a spheroid whose red hue, in the light of this sun, became like that of clotted blood. Out of it and across the kilometers between darted small fierce gleams that swelled into space-combat armor enclosing creatures larger than men. They numbered a dozen, and each bore at least two firearms.

Obedient to orders, Ryan operated the main personnel airlock and cycled four of them through. The first grabbed him and slammed him against the bulkhead so hard that it rang. Stunned, he would have slumped to

the deck were it not for the bruising grip on his shoulders. The next two crouched with weapons ready. The last one took over the controls and admitted the remaining eight.

At once, ten went off in pairs to ransack the ship. It was incredible how fast they carried the mass of metal upon them. Their footfalls cast booming echoes down the passageways.

Markham and Tregennis, waiting in the saloon, were frisked and put under guard. Presently Ryan was brought to them. "My maiden aunt has better manners than they do," he muttered, and lurched toward the bar. The kzin used his rifle butt to push him into a chair and gestured for silence. Time passed.

Within an hour, which felt longer to the humans, the boarding party was satisfied that there were no traps. Somebody radioed a report from the airlock; the rest shed their armor and stood at ease outside the saloon. Its air grew full of their wild odor.

A new huge and ruddy-gold form entered. The guard saluted, sweeping claws before his face. Markham jumped up. "For God's sake, stand," he whispered. "That's the captain."

Tregennis and, painfully, Ryan rose. The kzin's gaze flickered over them and came back to dwell on Markham, recognizing leadership. The Wunderlander opened his mouth. Noises as of a tiger fight poured forth.

Did the captain register surprise that a man knew his language? He heard it out and spat a reply. Markham tried to continue. The captain interrupted, and Markham went mute. The captain told him something.

Markham turned to his companions. "He forbids me to mangle the Hero's Tongue any more," he related wryly. "He grants my request for a private talk—in the communications shack, where our translator is, since I explained that we do have one and it includes the right program. Meanwhile you may talk with each other and move freely about this cabin. If you must relieve yourselves, you may use the sink behind the bar."

"How gracious of him," Ryan snorted.

Markham raised brows. "Consider yourselves fortunate. He is being indulgent. Don't risk provoking him. High-ranking kzinti are even more sensitive about their honor than the average, and he has earned a partial name, Hraou-Captain."

"We will be careful," Tregennis promised. "I am sure you will do your best for us."

The commander went majestically out. Markham trailed. Ryan gusted a sigh, sought the bar, tapped a liter of beer, and drained it in a few gulps. The guard watched enviously but then also left. Discipline had prevented him from shoving the human aside and helping himself. He and a couple of his fellows remained in the passage. They conversed a bit, rumbling and hissing.

"We'll be here a while," Ryan sighed. "Care for a round of gin?"

"It would be unwise of us to drink," Tregennis cautioned. "Best you be content with that mugful you had."

"I mean gin rummy."

"What is that, if not a, ah, cocktail?"

"A card game. They don't play it on Plateau? I can teach you."

"No, thank you. Perhaps I am too narrow in my interests, but cards bore me." Tregennis brightened. "However, do you play chess?"

Ryan threw up his hands. "You expect me to concentrate on woodpushing *now*? Hell, let's screen a show. Something light and trashy, with plenty of girls in it. Or would you rather seize the chance to at last read *War and Peace*?"

Tregennis smiled. "Believe it or not, Kamehameha, I have my memories. By all means, girls."

The comedy was not quite finished when a kzin appeared and jerked an unmistakable gesture. The men followed him. He didn't bother with a companion or with ever glancing rearward. At the flight deck he proceeded to Saxtorph's operations cabin, waved them through, and closed the door on them.

Markham sat behind the desk. He was very pale and reeked of the sweat that stained his tunic, but his visage

was set in hard lines. Hraou-Captain loomed beside him, too big to use a human's chair, doubtless tired of being cramped in the comshack and maybe choosing to increase his dominance by sheer height. Another kzin squatted in a far corner of the room, a wretched-looking specimen, fur dull and unkempt, shoulders slumped, eyes turned downward.

"Attention," rasped Markham. "I wish I did not have to tell you this—I hoped to avoid it—but the commander says I must. He . . . feels deception is pointless and . . . besmirches his honor. His superior on Secunda agrees; we have been in radio contact."

The newcomers braced themselves.

Nonetheless it was staggering to hear: "For the past five years I have been an agent of the kzinti. Later I will justify myself to you, if your minds are not totally closed. It is not hatred for my species that drove me to this, but love and concern for it, hatred for the decadence that is destroying us. Later, I say. We dare not waste Hraou-Captain's time with arguments."

Regarding the faces before him, Markham made his tone dry. "The kzinti never trusted me with specific information, but after I began sending them information about hyperdrive technology, they gave me a general directive. I was to use my position as commissioner to forestall, whenever possible, any exploration beyond the space containing the human-occupied worlds. That naturally gave me an inkling of the reason—to prevent disclosure of their activities—and it became clear to me that some of the most important must be in regions distant from kzin space. When hope was lost of keeping you from this expedition, I decided my duty was to join it and stand by in case of need. Not that I anticipated the need, understand. The star looked so useless. But when you did get those radio indications, I knew better than you what they could mean, and was glad I had provided against the contingency, and beamed a notice of our arrival."

"Your parents were brothers," Ryan said.

Markham laid back his ears. "Spare the abuse. Re-

member, by forewarning the kzinti I saved your lives. If you had simply blundered into detector range—"

"They may be impulsive," Tregennis said, "but they are not idiotic. I do not accept your assertion that they would reflexively have annihilated us."

Markham trembled. "Silence. Bear in mind that I am all that stands between you and—It has been a long time since the kzinti in this project tasted fresh meat."

"What are they doing?" Ryan asked.

"Constructing a naval base. They chose the system precisely because it seemed insignificant—the dimmest star in the whole region, devoid of heavy elements and impoverished in the light—though it does happen to have a ready source of iron and certain other crucial materials, together with a strategic location. They never expected humans to seek it out. They underestimated the curiosity of our species. They are . . . cats, not monkeys."

"Uh-huh. Not noisy, sloppy, free-swinging monkeys like you despise. Kzinti respect rank. Once they've overrun us, they'll put the niggers back in their proper place. From here they can grab off Beta Hydri, drive a salient way into our space—How many more prongs will there be to the attack? When is the next war scheduled for?"

"Silence!" Markham shouted. "Hold your mouth! One word from me, and—"

"And what? You need us, Art and me, you need us, else we wouldn't be having this interview. Kill us, and your boss just gets a few meals."

"Killing can be in due course. I imagine he would enjoy your testicles for tomorrow's breakfast."

Ryan rocked on his feet. Tregennis' lips squeezed together till they were white.

Markham's voice softened. "I am warning, not threatening," he said in a rush. "I'll save you if I can, unharmed, but if you don't help me I can promise nothing."

He leaned forward. "Listen, will you? Obviously you can't be released to spread the news—not yet—but some years of detention are better than death." He

could not quite hold back the sneer. "In *your* minds, I suppose. You're lucky, lucky that I was aboard. Once my status has been verified, the high commandant can let me bring home a convincing tale of disaster. Else he would probably have had to kill us and make our bodies stage props, as Saxtorph suggested. I think he will spare you if I ask; it will cost him little, and kzinti reward faithful service. They also keep their promises. But you must earn your lives."

"The boats," Tregennis whispered.

Ryan nodded. "You've got a telepath on hand, I see," he said flat-voiced. "He could make sure that my call in Hawaiian tells how everything is hearts and flowers. Except if he reads my mind, he'll see that I ain't gonna do it, no matter what. Or, okay, maybe they can break me, but Bob will hear that in his old pal's voice."

"I've explained this to Hraou-Captain," Markham said, cooler now. "It is necessary to neutralize those boats, but they don't pose any urgent threat, so we will start with methods less time-consuming than . . . interrogation and persuasion. Later, though, when we are on Secunda—that's where we are going—later your cooperation in working up a plausible disaster for me to return with, that is what will buy you your lives. If you refuse, you'll die for nothing, because we can always devise some deception which will keep humans away from here. You'll die for nothing."

"What the hell can we do about the boats? We don't know where they've gone."

Markham's manner became entirely impersonal. "I have explained this to Hraou-Captain. I went on to explain that their actions will not be random. What Captain Saxtorph decides—has decided to do is a multi-variable function of the logic of the situation and of his personality. You and he are good friends, Ryan. You can make shrewd guesses as to his behavior. They won't be certain, of course, but they will eliminate some possibilities and assign rough probabilities to others. Your input may have some value too, Professor. And

even mine—in the course of establishing that I have been telling the truth.

"Sit down on the deck. This will not be pleasant, you know."

Hraou-Captain, who had stood like a pillar, turned his enormous body and growled a command. The telepath raised his head. Eyes glazed by the drug that called forth his total abilities came to a focus.

In their different ways, the three humans readied for what was about to happen. They'd have sundering headaches for hours afterward, too.

13

Small though it was, at its distance from Prima the sun showed more than half again the disc which Sol presents to Earth. Blotches of darkness pocked its sullen red. Corona shimmered around the limb, not quite drowned out of naked-eye vision.

Yoshii ignored it. His attention was on the planet which *Fido* circled in high orbit. Radar, spectroscope, optical amplifier, and a compact array of other instruments fed data to a computer which spun forth interpretations on screen and printout. Klick and whirr passed low through the rustling ventilation, the sometimes uneven human breath within the control cabin. Body warmth and a hint of sweat tinged the air.

Yoshii's gaze kept drifting from the equipment, out a port of the globe itself. "Unbelievable," he murmured.

Airless, it stood sharp-edged athwart the stars, but the illuminated side was nearly a blank, even at first and last quarter when shadows were long. Then a few traces of hill and dale might appear, like time-worn Chinese brush strokes. Otherwise there was yellowish-white smoothness, with ill-defined areas of faint gray, brown, or blue. The whole world could almost have been a latex ball, crudely made for a child of the giants.

"What now?" Carita asked. She floated, harnessed in her seat, her back to him. They had turned off the

gravity polarizer and were weightless, to eliminate that source of detectability. Her attention was clamped to the long-range radar with which she swept the sky, to and fro as the boat swung around.

"Oh, everything," said the Belter.

"Any ideas? You've had more chance to think, these past hours, than I have."

"Well, a few things *look* obvious, but I wouldn't make book on their being what they seem."

"Why don't you give me a rundown?" proposed the Jinxian. "Never mind if you repeat what I've already heard. We should try putting things in context."

Yoshii plunged into talk. It was an escape of sorts from their troubles, from not knowing what the fate of *Shep* and those aboard her might be.

"The planet's about the mass of Earth but only about half as dense. Must be largely silicate, some aluminum, not enough iron to form a core. Whatever atmosphere and hydrosphere it once outgassed, it lost—weak gravity, and temperatures around 400 K at the hottest part of the day. That day equals 131 of Earth's; two-thirds rotational lock, like Mercury. No more gas comes out, because vulcanism, tectonics, all geology ended long ago. Unless you want to count meteoroid erosion wearing down the surface; and I'd guess hardly any objects are left that might fall on these planets.

"Then what is that stuff mantling the surface? The computer can't figure it out. Shadows of what relief there is indicate it's thin, a few centimeters deep, with local variations. Reflection spectra suggest carbon compounds but that's not certain. It just lies there, you see, doesn't do anything. Try analyzing a lump of some solid plastic across a distance. Is that what we have here, a natural polymer? I wish I knew more organic chemistry."

"Can't help you, Juan," Carita said. "All I remember from my class in it, aside from the stinks in the lab, is that the human sex hormones are much the same, except that the female is ketonic and the male is alcoholic."

"We'll have time to look and think further, of course."

Yoshii sighed. "Time and time and time. I never stopped to imagine how what fugitives mostly do is sit. Hiding, huddling, while—" He broke off and struggled for self-command.

"And we don't dare let down our guard long enough to take a little recreation," Carita grumbled.

Yoshii reddened. "Uh, if we could, I—well—"

She chuckled and said ruefully, "I know. The fair Laurinda. Don't worry, your virtue will be safe with me till you realize it can't make any possible diff—Hold!" she roared.

He tensed where he floated. "What?"

"Quiet. No, secure things and get harnessed."

For humming minutes she studied the screen and meters before her. Yoshii readied himself. Seated at her side he could see the grimness grow. Pale hair waved around sable skin when at last she nodded. "Yes," she said, "somebody's bound this way. From the direction of the sun. About ten million clicks off. He barely registered at first, but it's getting stronger by the minute. He's boosting *fast*. We'd tear our hull apart if we tried to match him, supposing we had that kind of power. Definitely making for Prima."

"What . . . is it?"

"What but a kzin ship with a monster engine? I'm afraid they've caught on to our strategy." Carita's tone grew wintry. "I'd rather not hear just how they did."

"G-guesswork?" Yoshii faltered.

"Maybe. I don't know kzin psych. How close to us can they make themselves think?" She turned her head to clamp her vision on him. "Well, maybe the skipper's plan failed and it's actually drawn the bandits to us. Or maybe it's the one thing that can save us."

(Saxtorph's words drawled through memory: "We don't know how much search capability the kzin have, but a naval vessel means auxiliaries, plus whatever civilian craft they can press into service. A boat out in the middle of the far yonder, drifting free, would be near-as-damn impossible to find. But as soon as she accelerates back toward where her crew might do something real,

she screams the announcement to any alert, properly organized watchers—optical track, neutrino emission, the whole works till she's in effective radar range. After that she's sold to the licorice man, as they say in Denmark. On the other hand, if she can get down onto a planetary surface, she can probably make herself almost as invisible as out in the deep. A worldful of topography, which the kzinti cannot have had time or personnel to map in anything but the sketchiest way. So how about one of ours goes to Prima, the other to Tertia, and lies low in orbit? Immediately when we get wind of trouble, we drop down into the best hidey-hole the planet has got, and wait things out."

(It had been the most reasonable idea that was broached.)

"You've been doing our latest studies," Carita went on. "Found any prospective burrows? The kzinti may or may not have acquired us by now. Maybe not. That vessel may not be as well equipped to scan as this prospector, and she's probably a good deal bigger. But they're closing in fast, I tell you."

Yoshii made a shushing gesture, swiveled his seat, and evoked pictures, profiles, data tabulations. Shortly he nodded. "I think we have a pretty respectable chance." Pointing: "See here. Prima isn't all an unbroken plain. This range, its small valleys—and on the night side, too."

Carita whistled. "Hey, boy, we live right!"

"I'll set up for a detailed scan and drop into low orbit to make it. We should find some cleft we can back straight down into. The kzinti would have to arc immediately above and be on the lookout for that exact spot to see us." Yoshii said nothing about what a feat of piloting he had in mind. He was a Belter. She had almost comparable experience, together with Jinxian reflexes.

"Yah, I do think our best bet is to land and snuggle in." Saxtorph's look ranged through the port and across the planet, following an onward sweep of daylight as *Shep* orbited around to the side of the sun.

That disc was less than half the size of Sol's at Earth, its coal-glow light little more than one one-hundredth. Nevertheless Tertia shone so brightly as to dazzle surrounding stars out of sight. Edges softened by atmosphere, it was bestrewn with glaciers, long streaks and broad plains and frozen seas bluishly aglimmer from pole to pole. Bared rock reached darkling on mountain-sides or reared in tablelands. Five Terrestrial masses had been convulsed enough as they settled toward equilibrium that the last of the heights they thrust upward had not worn away entirely during the post-tectonic eons.

The glaciers were water, with some frozen carbon dioxide overlying them in the antarctic zone where winter now reigned. The air, about twice as dense as Earth's, was almost entirely nitrogen, the oxygen in it insufficient to sustain fire or life. It was utterly clear save where slow winds raised swirls of glitter, dust storms whose dust was fine ice.

A small moon, inmost of four, hove in view. It sheened reddish-yellow, like amber. The largest, Luna-size, was visible too, patched with the same hue, ashen where highlands were uncovered. It had no craters; spalling and cosmic sand had long since done away with them.

"But, but on the surface we'll see only half the sky at best," Laurinda ventured. "And atmospherics will . . . hinder the seeing."

Saxtorph nodded. "True. Ordinarily I'd opt for staying in space in hopes of early warning. That does have its own drawbacks, though. A kzin search vessel could likelier than not detect us the moment we commenced boost. Since we might not be able to skedaddle flat-out from them, we'd probably drop planetside. That's the whole idea of being where we are, remember? If we

did it right, the ratcats wouldn't know where we'd squatted, but they'd know we were someplace yonder for sure, and that would be a bigger help to them than they deserve."

"Treacherous terrain for landing," Dorcas warned.

Saxtorph nodded again. "Indeed. Which means we'll be smart to take our time while we've still got it, come down cautiously and settle in thoroughly. As for knowing when a spacecraft is in the neighborhood, at a minimum there's our neutrino detector. It's not what you'd call precise, but it will pick up an operating fusion generator within a couple million clicks, clear through the body of the planet."

He paused before adding, "I realize this isn't quite what we intended when we said goodbye. But we didn't know what Tertia is like. Doctrine exists to be modified as circumstances dictate. I'd guess the sensible thing for Juan and Carita to do is quite different."

Laurinda's fingers twisted together. She turned her face from the other two.

"I vote with you," Dorcas declared. They had been considering tactics for hours, while they gained knowledge of the world they had reached. "What are the specs of a landing site? Safe ground; concealment from anything except an unlikely observation from directly overhead, unless we can avoid that too; but we don't want to be in a radio shadow, because we hope for—we expect—a broadcast message in the fairly near future."

"Don't forget defensibility," Saxtorph reminded.

"What?" asked Laurinda, startled. "How can we possibly—"

The man grinned. "I didn't tell you, honey, because it's not a thing to blab about, but Dorcas and I always travel with a few weapons. I took them along packed among my personal effects. Managed to slip Carita a rifle and some ammo when nobody else was looking. That leaves us with another rifle, a Pournelle rapid-fire automatic, choice of solid or explosive shells; a .38-caliber machine pistol with detachable stock; and a 9-mm. mulekiller."

"Plus a certain amount of blasting sticks," Dorcas informed him.

Saxtorph goggled. "Huh?" He guffawed. "That's my nice little wifey. The standard mining equipment aboard includes knives, geologists' hammers, crowbars, and such, useful for mayhem." He sobered. "Not that we want a fight. God, no! But if we're able to give a good account of ourselves—it might make a difference."

"A single small warhead will make a much bigger difference, unless we have dispersal and concealment capability," Dorcas observed. "All right, let's take a close look at what topographical data we've collected."

The choice was wide, but decision was quick. *Shep* dropped out of orbit and made for a point about 30 degrees north latitude. It was at midafternoon, which was a factor. Lengthening shadows would bring out details, while daylight would remain—in a rotation period of 40 hours, 37-plus minutes—for preliminary exploration of the vicinity.

A mesa loomed stark, thinly powdered with ice crystals, above a glacier that had flowed under its own weight, down from the heights, until a jumble of hills beneath had brought it to a halt. As it descended, the glacier had gouged a deep, almost sheer-walled coulee through slopes and steeps. The bottom was talus, under a dusting of sand, but solid; with gravity a third higher than on Earth, and epochs of time, shards and particles had settled into gridlock.

Or so the humans reasoned. The last few minutes of maneuver were very intent, very quiet except for an occasional low word of business. Saxtorph, manning the console, was prepared to cram on emergency boost at the first quiver of awryness. But Dorcas talked him down and *Shep* grounded firmly. For a while, nobody spoke or moved. Then husband and wife unharnessed and kissed. After a moment, Laurinda made it a three-way embrace.

Saxtorph peered out. The canyon walls laid gloom over stone. "You ladies unlimber this and stow that

while I go take a gander," he said. "Yes, dear, I won't be gone long and I will be careful."

His added weight dragged at him, but not too badly. It wasn't more than physiology could take, even a Belter's or a Crashlander's, and distributed over the whole body. The women would get used to it, sort of, and in fact it ought to be valuable, continuous exercise in the cramped quarters of the boat. The spacesuit did feel pretty heavy.

He cycled through and stood for a few minutes learning to see the landscape. Every cue was alien, subtly or utterly, light, shadow, shapes. The cobbles underfoot were smooth as those on a beach. They and the rubble along the sides and the cliffs above were tawny-gray, sparked with bits of what might be mica but was likelier something strange—diamond dust? Several crags survived, eroded to laciness. The lower end of the gorge, not far off, was blocked by a wall of glacier. Above reached purple sky. An ice-devil whirled on the heights. Wind whittered.

Saxtorph decided his party had better plant an antenna and relay inconspicuously up there. Any messages ought to be on a number of simultaneous bands, at least one of which could blanket a Tertian hemisphere, but the signal would be tenuous and these depths might screen it out altogether. He walked carefully from the arrowhead of the boat to the right-hand side and started downslope, looking for safe routes to the top. Lateral ravines appeared to offer them.

Abruptly he halted. What the flapping hellfire?

He stooped and stared. Could it be—? No, some freak of nature. He wasn't qualified to identify a fossil.

He went on. By the time he had tentatively found the path he wanted, he was so near the glacier that he continued. It lifted high, not grimy like its counterparts on terrestroid planets but clear, polished glassy-smooth, a cold and mysterious blue. Whatever mineral grains once lay on it had sunken to the bottom, and—

And—

Saxtorph stood moveless. The time was long before he breathed, "Oh. My. God."

From within the ice, the top half of a skull stared at him. It could only be that, unhuman though it was. And other bones were scattered behind, and shaped stones, and pieces of what was most surely earthenware—

Chill possessed him from within. How old were those remnants?

Big Tertia must in its youth have had a still denser atmosphere than now, greenhouse effect, heat from a contracting interior, and . . . those molecules that are the kernel from which life grows, perhaps evolved not here but in interstellar space, organics which the wan sun did not destroy as they drifted inward. . . . Life arose. It liberated oxygen. It gave birth to beings that made tools and dreams. But meanwhile the planetary core congealed and chilled, the oceans began to freeze, plants died, nothing replaced the oxygen that surface rocks bound fast. . . . Without copper, tin, gold, iron, any metal they could know for what it was, the dwellers had never gone beyond their late stone age, never had a chance to develop the science that might have saved them or at least have let them understand what was happening. . . .

Saxtorph shuddered. He turned and hastened back to the boat.

15

Unsure what kind of surface awaited them, Carita and Yoshii descended on the polarizer and made a feather-soft landing. They were poised to spring instantly back upward. All they felt was a slight resilience, more on their instruments than in their bones. It damped out and *Fido* rested quiet.

"Elastic?" Yoshii wondered. "Or viscous, or what?"

"Never mind, we'll investigate later, right now we're down safe," Carita replied. She wiped her brow. "Hoo, but I need a stiff drink and a hot shower!"

Yoshii leered at her. "In the opposite order, please."

She cuffed him lightly. The horseplay turned into mutual unharnessing and a hug.

"Hey-y," she purred, "you really do want to celebrate, don't you? Later, we'll share that shower."

His arms dropped. She released him in her turn and he made a stumbling backward step. "I, I'm sorry, I didn't intend—Well, we should take a good look outside, shouldn't we?"

The Jinxian was briefly silent before she smiled wryly and shrugged. "Okay. I'll forgive you this time if you'll fix dinner. Your yakitori tacos are always consoling. You're right, anyway."

They turned off the fluoros and peered forth. As their eyes adapted, they saw well enough through airlessness, by the thronging stars and the cold rush of the Milky Way. Bowl-shaped, the dell in which they were parked curved some 50 meters wide to heights twice as far above the bottom. *Fido* sat close to one side; direct sunlight would only touch her for a small part of the day, weeks hence. Every edge and lump was rounded off by the covering of the planet. In this illumination it appeared pale gray.

"What is the stuff?" Carita muttered.

"I've hit on an idea," Yoshii said. "I do not warrant that it is right. It may not even make sense."

Her teeth flashed white in the darkness. "The universe is not under obligation to make sense. Speak your piece." She switched cabin illumination back on. Radiance made the ports blank.

"I think it must be organic—carbon-based," Yoshii said. "It doesn't remotely match any mineral I've ever seen or heard of or imagined, whereas it does resemble any number of plastics."

"Hm, yeah, I had the same thought, but discarded it. Where would the chemistry come from? Life can't have started in the short time *Prima* hung onto its atmosphere, can it? Whatever carbon, hydrogen, oxygen, nitrogen are left must be locked up in solid-state materials. At most we might find hydrates or something."

"This could have come from space."

"What?" She gaped at him. "If that's a joke, it's too deep for me."

"There is matter in space, in the nebulae and even in the emptiest stretches between. It includes organic compounds, some of them fairly complex."

"Not quite concentrated enough for soup."

"Sure, the densest nebula is still a pretty hard vacuum by Terrestrial standards. However, this system has had time to pass through many. Between them, too—yes, between galaxies—gravity has found atoms and molecules to draw in. During any single year, hardly a measurable amount. But it's been fifteen *billion* years, Carita."

"Um'h," she uttered, almost as if punched in the stomach.

"The sun doesn't give off any ultraviolet to speak of," Yoshii pursued. "Its wind is puny. Carbon-based molecules land intact. The sun does maintain a daytime temperature at which they can react with each other. I daresay cosmic radiation energizes the chemistry too. Fine grains of sand and dust—crumbled off rocks, together with meteoroid powder—provide colloidal surfaces where the stuff can cluster till there's a fairly high concentration and complicated exchanges become possible. Unsaturated bonds grab the free atoms of carbon, hydrogen, oxygen, anything included in the downdrift except noble gases, and incorporate them. Maybe, here and there, some such growing patch 'learns' how to take stuff from surface rocks. It's a slow, slow process—or set of processes—but it's had time. Eventually patches meet as they expand. What happens then depends on just what their compositions happen to be. I'd expect some weird interactions while they join. Those could be going on yet. That would explain why we saw differently colored areas. But it's only the terminal reactions."

Yoshii's words had come faster and faster. He was developing his idea as he described it. Excitement turned into awe and he whispered. "A polymer. A single multiplex molecule, the size of this planet."

Carita was mute for a whole minute before she mur-

mured, "Whew! But why isn't the same stuff on every airless body? . . . No, wait. Stupid of me to ask. This is the only one where conditions have been right."

Yoshii nodded. "I suspect that what yellows the rest is a carbon compound too, but something formed in space. You get some fairly complicated ones there, you know. If that particular one can't react with the organics I was talking about—too cold—then they are a minor part of the downdrift compared to it. We haven't noticed the same thing in other planetary systems because they are all too young, and maybe because none of them have made repeated passages through nebulae."

"You missed your calling," Carita said tenderly. "Should've been a scientist. Is it too late? We can go out, take samples, put 'em through our analyzers. When we get home, you can write a paper that'll have scholarships piled around you up to your bellybutton. Though I hope you'll keep on with the poetry. I like what you—"

A quiver went through the boat. "What the Finagle!" she exclaimed.

"A quake?" Yoshii asked.

"The profs told us these planets are as far beyond quakes as a mummy is beyond hopscotch," Carita snapped.

Another tremor made slight noises throughout the hull. Yoshii reached for the searchlight switch. Carita caught his arm. "Hold that," she said. "The kzinti—No, unless they beef up that already wild boost they are under, they won't arrive for a couple more hours." Nevertheless he refrained.

The pair studied their instrument panel. "We've been tilted a bit," Yoshii pointed out. "Should we reset the landing jacks?"

"Let's wait and see," Carita said. "I'd guess the rock beneath has settled under our weight, or one layer has slid over another, or something like that. If it's reached a new equilibrium, we don't want to upset it by shifting

mass around. No sense in moving yet, when we can't tell what the ground is like anywhere else."

"Right. I'm afraid, though, we can't relax as we'd hoped."

"How much relaxing could we do anyway, with kzinti sniffing after us?"

"And Laurinda—" Yoshii whispered. Harshly: "Do you want to take the controls, stand by to jump out of here, in case? I'll snug things down and, yes, throw a meal together."

Lightfoot under the low gravity, he descended aft to the engine compartment. Delicate work needed doing. The idling fusion generator must be shut down entirely, lest its neutrino smoke betray the boat—not that the kzinti could home on it, but they would know with certainty the humans were on Prima, and in which quadrant. Batteries, isotopic and crystalline as well as chemical, held energy for weeks of life support and ordinary operations. Yet it had to be possible to restart the generator instantly, full power within a second, should there be a sudden need to scramble. That meant disconnecting the safety interlocks. Yoshii fetched tools and got busy. The task was demanding, but not too much for his spirit to wing elsewhere in space, elsewhere in time—the Belt, Plateau, We Made It, *Rover's* folk on triumphal progress after their return. . . .

Carita's voice came over the intercom. "This is dull duty. I think I will turn on the searchlight while it's still safe to do so. Might get a clue to what caused those jolts."

"Good idea," he agreed absent-mindedly, and continued his task.

The metal around him throbbed. Small objects rattled on the deck.

"Juan!" Carita shouted. "The, the material—it's rippling, crawling—" The hull rocked. "I'm getting us out of here!"

"Yes, do," he called back, and grabbed for the nearest handhold.

Within its radiation shield, the generator hummed.

Needles sprang across dials, displays onto screens. Yoshii felt the upward thrust of the deck against his feet. It was slight. Carita was a careful pilot, applying barely sufficient boost to rise off the ground before she committed to a leap.

The boat screamed. Things tilted. Yoshii clung. Loose things hailed around him. A couple of them drew blood. The boat canted over, toppled, struck lengthwise, tolled so that he was half deafened.

Stillness crashed down, except for a shrill whistle that he knew too well. Air was escaping from one or more rents nearby. He hauled himself erect and out of his daze. The emergency valve had already shut, sealing off this section. He had to get through the lock built into it before the pressure differential made operation fatally slow.

Somehow he passed forth, and on along the companionway that was now a corridor, toward the control cabin. Lights were still shining, ventilators still whirling, and few articles lay strewn around. This was a good, sturdy craft, kept shipshape. How had she failed?

Carita met him in the entrance. "Hey, you sure got battered, didn't you? I was secured. Here, let me help you." She practically carried him to his chair, which she had adjusted for the new orientation. Meanwhile she talked on: "The trouble's with the landing gear, I think. Is that damn stuff a glue? No, how could it be? Take over. I'm going to suit up and go out for a look."

"Don't," he protested. "You might get stuck there too."

"I'll be careful. Keep watch. If I don't make it back—" She stooped, brushed lips across his, and hurried aft.

His ears rang and pained him, his head ached, he was becoming conscious of bruises, but his eyes worked. The searchlight made clear the motion in the mantle. It was slight in amplitude, as thin as the layer was, and slow, but intricate, like wave patterns spreading from countless centers to form an ever-changing *moiré*. Those nodes were darker than the ripple-shadows and seemed to pass the darknesses on from one to the next, so that a

shifting stipple went outward from the boat, across the dell floor and, as he watched, up the side. The hull rocked a little, off and on, in irregular wise.

"Do you read me?" he heard after a while. "I'm in the Number Two lock, outer valve open, looking over the lip."

"I read you," he answered unevenly. At least the radio system remained intact. "What do you see?"

"The same turbulence in the . . . stuff. Nothing clear aft, where the main damage is. The searchbeam doesn't diffuse, and—I'm off to inspect."

"Better not. If you lost your footing and fell down into—"

She barked scorn. "If you think I could, then I'm for sure the right person for this job." He clenched his fists but must needs admit that induction boots gave plenty of grip on the metal for a rockjack—a rockjill, she often called herself. "I'm crawling out. . . . Standing. . . . On my way." The hull pitched. "Hey! That damn near threw me." Starkly: "I think *Fido* just settled more at the after end."

"But into what?" he cried. "Solid rock?"

"No, I guess not. I do know what we *are* deep down into. . . . Okay, proceeding. Landing gear in sight now, spraddled against the sky. It's dark, I can't see much except stars. Let me unlimber my flashlight. . . . A-a-ah!" she nearly screamed.

He half rose in his seat. "What happened? Carita, dear, are you there?"

"Yes. A nasty shock, that sight. Listen, the Number Three leg is off the ground. The bottom end sticks up—ragged, holes in it—like a badly corroded thing that got so weak it tore apart when it came under stress. . . . But Juan, this is melded steel and titanium alloy. What could've eaten it?"

"We can guess," Yoshii said between his teeth. "Come back."

"No, I need to see the rest. Don't worry, I'll creep down the curve like a cat burglar. . . . I'm at the socket of Number Two. I'm shining my light along it. Yes.

Nothing left of the foot. Seems to be sort of—absorbed into the ground. Number One—more yet is missing, and, yes, that's the unit which pulled partly loose from its mounting and made the hole in the engine compartment. I can see the skin ripped and buckled—"

The boat swayed. Her nose twisted about and lifted a few degrees as her tail sank. Groans went through the hull.

"I'm okay, mate. Well anchored. But holy Finagle! The stuff is going wild underneath. Has it come to a boil?"

Yoshii could not see that where he was, but he did spy the quickening and thickening of the wave fronts farther off. Understanding blasted him. "Douse your flash!" he yelled. "Get back inside!" He grabbed for the searchlight switch as for the throat of a foe.

"Hey, what is this?" Carita called.

"Douse your flash, I said. Can't you see, bright light is what causes the trouble? Find your way by the stars." He clutched his shoulders and shivered in the dark. The boat shivered with him, diminuendo.

"I read you," Carita said faintly.

Yoshii darkened the cabin as well. "Let's meet in my stateroom," he proposed. The sarcastically named cubbyhole did not give on the outside. He groped till he found it. When again he dared grant himself vision, he bent above the locker where a bottle was, shook his head, straightened, and stood looking at a photograph of Laurinda on the bulkhead.

Carita entered. Her coverall was wet and pungent. Sweat glistened on the dark face. "Haven't you poured me a drink?" she asked hoarsely.

"I decided that would be unwise."

"Maybe for you, sonny boy. Not for me." The Jinxian helped herself, tossed off two mouthfuls, and sighed. "That's better. Thank you very much."

Yoshii gestured at his bunk. It was roughly horizontal, that being how the polarizer field was ordinarily set in flight. They sat down on it, side by side. Her bra-

vado dwindled. "So you know what's happened to us?" she murmured.

"I have a guess," Yoshii replied with care. "It depends on my idea of the supermolecule being correct."

"Say on."

"Well, you see, it grew. Or rather, I think, different ones grew till they met and linked up. There must have been all possible combinations, permutations of radicals and bases and—every kind of chemical unit. Cosmic radiation drives that kind of change. So does quantum mechanics, random effects; that was probably dominant in intergalactic space. So the chemistry . . . mutated. Whatever structure was better at assimilating fresh material would be favored. It would grow at the expense of the rest."

Carita whistled. "Natural selection, evolution? You mean the stuff's alive?"

"No, not like you and me or bacteria or even viruses. But it would develop components which could grab onto new atoms, and other components that are catalytic, and—and I think ways of passing an atom on from ring to ring until it's gone as far as there are receptors for it. That would leave room for taking up more at the near end. Because I think finally the molecule evolved beyond the point of depending on whatever fell its way from the skies. I think it began extracting matter from the planet, whenever it spread to where there was a suitable substance. Breaking down carbonates and silicates and—and incorporating metallic atoms too. Clathrate formation would promote growth, as well as chemical combination. But of course metal is ultra-scarce here, so the molecule became highly efficient at stealing it."

"At eating things." Carita stared before her. "That's close enough to life for me."

"The normal environment is low-energy," Yoshii said. "Things must go faster during the day. Not that there is much action then, either; nothing much to act on, any more. But we set down on our metal landing gear, and pumped out light-frequency quanta."

"And it . . . woke."

Yoshii grimaced but stayed clear of semantic argument. "It must be strongly bound to the underlying rock. It was quick to knit the feet of our landing jacks into that structure."

"And gnaw its way upward, till I—"

He caught her hand. "You couldn't have known. I didn't."

The deck swayed underfoot. The liquor sloshed in Carita's glass. "But we're blacked out now," she protested, as if to the devourer.

"We're radiating infrared," Yoshii answered. "The boat's warmer on the outside than her surroundings. Energy supply. The chemistry goes on, though slower. We can't stop it, not unless we want to freeze to death."

"How long have we got?" she whispered.

He bit his lip. "I don't know. If we last till sunrise we'll dissolve entirely soon after, like spooks in an ancient folk tale."

"That's more than a month away."

"I'd estimate that well before then, the hull will be eaten open. No more air."

"Our suits recycle. We can jury-rig other things to keep us alive."

"But the hull will weaken and collapse. Do you want to be tossed down into . . . that?" Yoshii sat straight. Resolution stiffened his tone. "I'm afraid we have no choice except to throw ourselves on the mercy of the kzinti. They must have arrived."

Carita ripped forth a string of oaths and obscenities, knocked back her drink, and rose. "*Shep* is still on the loose," she said.

Yoshii winced. "Man the control cabin. I'm going to suit up and get back into the engine compartment."

"What for?"

"Isn't it obvious? The energy boxes are stored there."

"Oh. Yes. You're thinking we'll have to take orbit under our own power and let the kzinti pick us up? I'm not keen on that."

"Nor I. But I don't imagine they'll be keen on landing here."

He rejoined her an hour later. By starlight she saw how he trembled. "I was too late," dragged from him. "Maybe if I hadn't had to operate the airlock hydraulics manually—What I found was a seething mass of—of—The entire locker where the boxes were is gone."

"That fast?" she wondered, stunned, though they had been in communication until he passed through into the after section. And then, slowly: "Well, the capacitors in those boxes are—were fully charged. Energy concentrated like the stuff's never known before. Too bad so much didn't poison it. Instead, it got a kick in the chemistry making it able to eat everything in three gulps. We're lucky the life-support batteries weren't there too."

"Let's hope the kzinti want us enough to come down for us."

Shielding a flashlight with a clipboard, they activated the radio, standard-band broadcast. Yoshii spoke. "SOS. SOS. Two humans aboard a boat, marooned," he said dully. "We are sinking into a—solvent—the macromolecule—You doubtless know about it. Rescue requested."

"We can't lift by ourselves. The drive units in our spacesuits have only partial charge, insufficient to reach orbital speed in this field. We can't recharge. That equipment is gone. So are all the reserve energy boxes. We can flit a goodly distance around the planet or rise to a goodly height, but we can't escape."

"Please take us off. Please inform. We will keep our receiver open on this band, and continue transmission so you can locate us."

Having recorded his words, he set them to repeat directly on the carrier wave and leaned back. "Not the most eloquent speech ever made," he admitted. "But they won't care."

She took his hand. Heaven stood gleamful above them. Time passed. Occasionally the vessel moved a bit.

A spaceship flew low, from horizon to horizon. They had only the barest glimpse. Perhaps cameras took note of theirs.

Carita choked. "Alien."

"Kzin," Yoshii said. "Got to be."

"But I never heard of anything like—"

"Nor I. What did you see?"

"Big. Sphere with fins or flanges or—whatever they are—all around. Mirror-bright. Doesn't look like she's intended for planetfall."

Yoshii nodded. "Me too. I wanted to make sure of my impression, as fast as she went by. Just the same, I think we have a while to wait." He stood up. "Suppose I go fix us some sandwiches and also bring that bottle. We may as well take it easy. We've played our hand out."

"But won't they—Oh, yes, I see. That's no patrol craft. She was called off her regular service to come check Prima. We being found, she'll call Secunda for further orders, and relay our message to a translator there."

"About a five-minute transmission lag either way, at the present positions. A longer chain-of-command lag, I'll bet. Leave the intercom on for me, please, but just for the sake of my curiosity. You can talk to them as well as I can."

"There isn't a lot to say," Carita agreed.

Yoshii was in the galley when he heard the computer-generated voice: "Werlith-Commandant addressing you directly. Identify yourselves."

"Carita Fenger, Juan Yoshii, of the ship *Rover*, stuck on Prima—on Planet One. Your crew has seen us. I suppose they realize our plight. We're being . . . swallowed. Please take us off. If your vessel here can't do it, please dispatch one that can. Over."

Silence hummed and rustled. Yoshii kept busy.

He was returning when the voice struck again: "We lost two boats with a total of eight heroes aboard before we established the nature of the peril. I will not waste time explaining it to you. Most certainly I will not hazard another craft and more lives. On the basis of observations made by the crew of *Sun Defier*, if you

keep energy output minimal you have approximately five hundred hours left to spend as you see fit."

A click signalled the cutoff.

Werlith-Commandant had been quite kindly by his lights, Yoshii acknowledged.

He entered the control cabin. "I'm sorry, Carita," he said.

She rose and went to meet him. Starlight guided her through shadows and glinted off her hair and a few tears. "I'm sorry too, Juan," she gulped. "Now let's both of us stop apologizing. The thing has happened, that's all. Look, we can try a broadcast that maybe they'll pick up in *Shep*, so they'll know. They won't dare reply, I suppose, but it's nice to think they might know. First let's eat, though, and have a couple of drinks, and talk, and, and go to bed. The same bed."

He lowered his tray to the chart shelf. "I'm exhausted," he mumbled.

She threw her arms around him and drew his head down to her opulent bosom. "So'm I, chum. And if you want to spend the rest of what time we've got being faithful, okay. But let's stay together. It's cold out there. Even in a narrow bunk, let's be together while we can."

LORD RIFKIN'S RISK

Melding as it does humor-laden matter-of-factness with more than just a touch of strange, this story is as nice a slice of galactic life as you are likely to find. I must say, however, that I require a higher degree of serious-mindedness from my luggage than does the otherwise estimable Lord Rifkin.

—JPB

LORD RIFKIN'S RISK

Ralph Roberts

The whispered real estate ads seemed commonplace enough:

FOR SALE OR LEASE, CURRENTLY VACANT SYNCHRONOUS ORBITAL SLOT. IMMEDIATE OCCUPANCY. OR WILL BUILD TO YOUR SPECIFICATIONS . . . ORION AGENCY, ORION STATION.

FORMER MILITARY SATELLITE FOR SALE BY OWNER. LIVING QUARTERS FOR TWENTY THOUSAND. MANY TRACKING AND INTELLIGENCE COMPUTERS STILL IN PLACE. ALSO WORKSHOPS AND LANDING BAYS FOR SHIPS UP TO EMPIRE DESTROYER CLASS . . . CONTACT TEMPLE MANHOME, SECTARIAN AFFAIRS DIVISION, BUREAU OF EMPIRE LIQUIDATION, NEW CHICAGO, EARTH.

FOR RENT, EXTENSIVE LIGHT INDUSTRY OR WAREHOUSING SPACE IN ELLFIVE GENELEC. REASONABLE RATES. ALSO SPACE IN OTHER ELLFIVES . . . HIRAM HOROWITZ, AGENT. 10455 TEN THOUSAND LEVEL, ELLFIVE GENELEC.

Lomar Rifkin gently squeezed the tiny news cube to cease its murmuring and mark his place. He moodily returned it to the pocket of his now somewhat-the-

worse-for-wear blue shipsuit and, leaning over the cabbie's shoulder, gazed at the vast construct beginning to take on detail in the front viewscreen. The view of cloud-bedecked Earth, on the rearward screen, interested him not. He would not be welcome *there*.

The cabbie, who had introduced himself only as Brown Eddie, grunted and removed the half-chewed, unlit nicostick from his mouth. He regarded it fondly for a moment, then dropped it to the deck to find instant companionship with several of its kind.

"A rich young lord like yourself," Brown Eddie commented, as he swiveled his command chair to face Lomar, who withdrew slightly, "should waste not his valuable time in flitting about these ancient and mostly deserted spacehulks."

Lomar regarded him silently. Brown Eddie shrugged and, under Lomar's dispassionate scrutiny, nervously tugged at the soiled brown shipsuit wrinkling itself about his stocky frame. His skin was equally brown and his hairless scalp, in the manner currently fashionable in Earth system, was adorned by a skin-tone design of brown and yellow. This, too, was less than neat.

Behind Brown Eddie, the cab's computer muttered to itself as final approach to Ellfive Genelec was automatically initiated.

"Ah . . . that is to say," continued Brown Eddie, suddenly not so sure of his mark, "that certain transportation services might be offered in return for the proper monetary incentives." As if by accident, Brown Eddie let one hand brush against the rearward screen where floated Earth, Temple Manhome, in three-dimensional representation.

"I find this of no interest," Lomar stated, his eyes drifting to the forward screen.

The vast bulk of Ellfive Genelec now filled the field of view, towering mightily above and below, curving gradually away right and left. On one uncluttered surface, perhaps a square kilometer in area but dwarfed by the rest of the ellfive, could still be discerned the ancient 'GE' trade symbol. Lomar nodded to himself,

feeling a quiet thrill of history come to life. Viewing books on the subject a hundred light-years away was one thing; to be here, another.

But Brown Eddie misinterpreted the nod. True, he was thinking, this young lordling was attired in a shipsuit that looked not much better than his own. And, indeed, he had but the one cheap travel bag, which was even now bumbling about in the cab's small cargo locker and whining ill-manneredly to be let out.

This tall young man, so surmised Brown Eddie, showed the presence of one born to lead. Or better, one who *had* led. His almost black eyes seemed to flash on occasion as if an inner fire was barely concealed. He wore head hair in the manner of one from outsystem, and the fact that the brown locks were long indicated high station in life. The younger son of a Trader Prince? On a quest to further prove his mettle?

The cab's computer beeped that docking was accomplished. Brown Eddie tried yet again.

"Young lord, this vessel possesses the capacity of landing on planetary surfaces." He modestly indicated himself with one hand as the other waved a fresh nicostick for emphasis. "And its owner has contacts in certain remote areas, where datacubes are not too closely scanned until certain changes are implemented to make them more acceptable. Utilizing such techniques, a protracted stay is possible. This service, while not inexpensive, is well within the means of one with your resources."

Brown Eddie felt the force of Lomar's attention return fully to him. But the deep fire in the young man's eyes was now the friendly kind that warmed. Brown Eddie began to see the person behind the presence.

"You misjudge me," Lomar said, smiling. "I am as you see, a creditless vagabond in search of work. And even were I not, why risk performing a capital offense by treading the soil of Earth?"

"Everybody desires to do so," asserted Brown Eddie, not believing Lomar's disclaimer. "That is where all of humankind wants to live." And through Brown Eddie's

mind flashed yet again his own dream of accumulating enough credit points to gain communion—to be accepted as Holy Resident of Temple Manhome.

"Perhaps," Lomar said, while handing over his funds transfer card, "you see the matter from a closer viewpoint than the billions who dwell happily about other stars."

Brown Eddie shrugged good-naturedly and passed the card through his cab's reader slot. Only young lords had such interstellar credit instruments. He was not going to let this one get away.

Lomar accepted the return of his card and surreptitiously ran his thumb over the 'credit remaining' window. His face remained impassive as he read the low total and replaced the card in his pocket. He stood.

"Release my luggage, if you please."

Brown Eddie caused the cab's computer to do so and also to dilate the hatch.

Lomar nodded and surveyed the vast, ill-lighted entrance area. A smell of great but magnificent age welled through the hatchway. His travel bag bounded about his feet and rubbed his legs in joyous reunion.

Brown Eddie also stood, shaking his head in bafflement.

"These old ruins are most dangerous for the uninitiated. Their gravity generators vary widely. Individuals of less than law-abiding demeanor roam darkened corridors. Why should you wish habitation here when green, green Earth is but a short journey away?"

Lomar pushed his bag from beneath his feet and stepped through the hatchway.

"It yet holds air, does it not?" he said, craning his head up to stare into the shadowed heights above. "And I feel no great gravity variations." His bag was exploring a small distance ahead.

Brown Eddie also stepped through the hatch and caused it to lock behind him.

"This ellfive," he conceded, "was better built than most. Genelec were mighty craftsbeings. Its dangers come not from environment but those who stalk in

unlighted and forgotten areas—who lurk waiting for the unwary." He clenched his latest nicostick, still unlit, between surprisingly white teeth—when one considered his habits—and grinned. "Then, too, there are the Genies."

Before and behind Lomar, broken at frequent intervals by docking facilities and other machinery, he could see the decking of the ellfive's outermost level curving upward. Only in the very far, dimly lit distance did the floor pass from his view, obscured by the high ceilings. It all brought to mind some immense artificial cavern. Great cargo handling devices hung like huge machined stalactites from high overhead, and the docks rose as metallic stalagmites to mate conveyor belts and pipelines.

But this fantastic and efficient cargo handling area had been silent for a hundred years. Lomar shook his head, remembering his studies of the glories that had been. Now, all was covered by the dust of decades and the only things moving were Brown Eddie, himself, and his luggage.

"This place must have been quite impressive in the old times," he said, "when they spun the whole vast cylinder for artificial gravity. But then, it was Genelec, themselves, who developed grav generators right here."

Ancient history had no appeal for Brown Eddie; he waved off Lomar's attempt at further lectures. "If the young lord must continue this foolhardy expedition, then I offer my abilities as guide until such time as you decide to avail yourself of my special services."

Lomar sighed. "Again, I have no wish to visit Earth. And having assimilated several reference works on Ellfive Genelec, I hardly need a guide. Thank you for the fast trip. I bid you good day." He started to turn away.

"For a small fee," Brown Eddie said quickly, determined to hang on to this young nobleperson, "I'll remain here so you'll have transport back to the interstellar craft I picked you off of . . ." His expression grew crafty and he tapped his nicostick knowingly. "Or wherever should be your desire."

Lomar smiled and shook his head no. He felt no need

of Brown Eddie's offer to guide. As to the proffered voyage to Earth, the authorities would be more inclined to mete out instant death to him than to the normal outworlder defacing their sacred atmosphere by mere breathing of same. Additionally, his finances were now at such low ebb that departure from this ellfive was impossible save after successful completion of his plan.

"Not necessary," he answered Brown Eddie, smiling in spite of his resolve to appear cool and dissuade this persistent cabbie. The fellow, though obviously in relentless pursuit of credit, did have a winning way about him that shone through his shoddy exterior.

Brown Eddie shrugged. This tall one was not so easy to pry credits from, but he found himself liking the young man even more. And these old ellfives really were less than safe—especially Ellfive Genelec.

"In that case, I offer my service gratis for a short period. A sample of my worth."

"Tag along, if you will," answered Lomar, secretly glad of the companionship. This level was so echoingly empty as to be eerie. "I must go to Ten Thousand level. What is your assessment as to the quickest route?"

With a wave of hand, Brown Eddie indicated direction and they set off, followed closely by Lomar's bag.

"This outermost level is Twelve Thousand," he explained. "Ten Thousand is two levels in toward center."

Lomar nodded. "I am familiar with their numbering system. But what are these 'Genies' you mentioned earlier?"

"Ah . . . a bit late to detail fully," Brown Eddie spoke, as three white-robed forms seemed to glide from behind a nearby pile of long-silent cargo handling devices. "Suffice to say that they are religious fanatics."

"As on earth?" asked Lomar, surveying the three approaching, as he could now discern, females.

"Less immediately violent," assured Brown Eddie, then hastened to add: "Though I am able to provide a way around overzealous regulations of Temple Manhome."

"Later," said Lomar, bowing slightly as the three figures halted before him. His bag cowered cravenly

behind his left knee. Even Brown Eddie stepped slightly backwards.

They were quite comely young ladies, tall and blond, like enough to be sisters. Their eyes were deep blue and lips soft red but cold smiling, their white robes alike with the ancient, respected 'GE' trade symbol above each right breast, the only difference being what Lomar recognized as stylized divisional logos over left breast. These were respectively "household appliances," "lighting," and "entertainment."

The three Genies spoke so close together as to almost sound as one.

"Progress was . . ."

"Progress is . . ."

"Progress will be . . ."

And all in unison: "Our most important business."

Three pairs of eyes boldly gazed on Lomar. The center Genie spoke first, the others adding comments so fast it sounded again like one person speaking.

"The brown person we know."

". . . It is dirty Brown Eddie."

". . . He drops mouth-mangled nicosticks on our decking."

Lomar essayed another courtly bow. "Allow me to introduce myself. I am Lomar Rifkin, currently of no fixed address, on a pilgrimage to Ellfive Genelec."

"A pilgrim?"

". . . None have come for so long."

". . . But this one brings pursuers, not to mention disgusting Brown Eddie."

"What pursuit?" Brown Eddie asked nervously. "I detected none such."

The three Genies ignored him and continued to address Lomar, the center one again leading off.

"I am Genie Jill. May Genelec light up your life."

"I am Genie Lynn. May music fill your being."

"I am Genie Sue. Press you, my son."

Lomar acknowledged each with a nod. "Do you not mean, 'bless'?" he asked Genie Sue. And all three answered.

"Oh, no."

"... Genie Sue is 'household appliances'."

"... May Genelec press your life so that it be wrinkle-free."

"Thank you," replied Lomar, with a courteous smile. "Now, despite long study of Ellfive Genelec, I must admit to ignorance of your no doubt holy religion. The records available to me covered mostly long past times, not events in detail of the last century or so. But my business here is simple. I come to consult briefly with one Hiram Horowitz, 10455 Ten Thousand level."

"He is our agent."

"... Ineffective."

"... Indecisive."

"Regardless," Lomar said, "it is him that I must confer with."

"But those who follow you."

"... They come with weapons."

"... They will rudely demand entry."

"I saw no one!" Brown Eddie stated again forcefully, miffed at being dismissed as worthless of consideration by the Genies.

"The Long Black Ships."

"... The Defenders of the Faith."

"... The false, false faith of Temple Manhome."

Lomar looked at Brown Eddie, and briefly raised one eyebrow in query.

Brown Eddie was suddenly nervous; best that he not be found here if the Defenders were interested in Ellfive Genelic. Too many awkward questions might be asked, and worse, credits deducted from his balance toward holy residency.

"They serve to enforce the Temple's will on the rest of the system," he answered Lomar. "While we are normally left unbothered up here, occasionally the long black ships range out to punish those that would defile Holy Manhome—like Marve Olafson, who let the orbit of his ratty entertainment satellite decay and enter the fringes of Holy Atmosphere. To him and his immediate associates was meted out slow death, and credits de-

ducted from all who had patronized him within the last year." A frown drove the nervousness from his face for an instant. "Four hundred credit points I lost. Two years work! Because Olafson couldn't be bothered to tune his grav generators properly. Is this fair? Is this. . . ."

Genie Jill waved her soft hand to terminate Brown Eddie's rambling. "They were not Genelec generators," she said, as if that was all the explanation needed. But added: "Those last for many centuries beyond the hallowed warranty's expiration."

Lomar nodded in agreement, enthusiasm reinforcing the politeness. "Many were the GE products owned by my father." His eyes glazed as if seeing far vistas. "Among our fleet, when I was small, we had three Schenectady-class merchant ships—the *Ufid* and the *Cedi*, called after the gold and green moons of my homeworld, and the *Maya*, which bore the name of my lady mother . . ." He paused and shrugged urbanely as if in apology. "Family fortunes have somewhat deteriorated since then, of course. Now we have no ships and my parents take their eternal rest by the shores of the Fragrant Sea."

The three Genies nodded and regarded him in silent sympathy, but Brown Eddie merely upped his assessment of this young lordling's worth. So what if he had had minor reverses? It was common knowledge that these Trader Princes had resources and abilities beyond that of the common being. Were there not tales of how they banded together to provide new capital for the fallen? Indeed, he was wise to attach himself. Brown Eddie believed strongly in the dribble-down theory, especially after one was so prudent as to assist fortune by punching the odd leak here and there.

A sudden thought hit Brown Eddie. One small problem yet remained, calling for immediate circumvention. In agitation, he reached unthinkingly for a nicostick, but his hand was forestalled by quiet hissing from the Genies.

He groaned, but let his hand drop. "The Defenders come," he reminded, then lifted his hand to tug at the left sleeve of Lomar's shipsuit. "This is no good. There

is nothing here for you. Come. With a slight head start, I can evade the long black ships by dashing here and there among the ellfives. There are many places known to me where they cannot maneuver sufficiently to follow."

Lomar brushed his hand away, attention on the three Genies who, now sure that Brown Eddie was not going to be dropping a nicostick on their floor, were smilingly concentrating on the tall Trader Prince. Obviously, from the misty looks and glint of interest in each eye, theirs was not a celibate priesthood.

"I have no interest in these Defenders," Lomar said, returning the interest shown by the three Genies. My, were they not lovely? Blond of hair and softly filling the three white gowns, the upthrust of each left breast emphasizing the separate symbols: "household appliances," "lighting," and "entertainment." These were ancient divisions of Genelec, existing even before the explosion of humankind across the galaxy.

He forced control on himself and gave Brown Eddie a significant glance. "Nor do the affairs of Temple Manhome engage my thoughts. Let them run Earth as they will. Here is as far as my concern in Homesystem runs."

The three Genies, as one, raised hands to silence the two men.

"They are here . . ."

"The ships dock . . ."

"Even now the ports open and the black-clad infidels enter these sacred precincts . . ."

"They carry weapons . . ."

"We have few defenses . . ."

"Defilement occurs . . ."

Again in unison, they beckoned and turned, moving off among the great silent machines in their long gowns as if floating effortlessly. Lomar and Brown Eddie quickly followed, luggage bumping along irritably behind. The bag seemed to sense the danger.

"We ascend here," said Genie Jill, indicating a large platform currently flush with the decking.

Lomar nodded graciously and stepped aboard with-

out hesitation, as did the three priestesses. Brown Eddie and Lomar's bag followed with somewhat greater trepidation. With no discernible action on anyone's part, the platform wafted slowly upwards toward Eleven Thousand level.

"Genelec Model Ten Heavy-Duty Freight Ascensor," Genie Jill said by way of explanation. "Assembly Line 12114 is still tooled up to manufacture them."

"Ummm," spoke Lomar, finding the exchange of intensive eye contact with the three Genies in turn a pleasant exercise as the ascensor rose smoothly. Which to choose? An impossible task. All were equally beautiful, equally desirable. Besides, it seemed that each had already made *her* choice—one Lomar Rifkin of presently doubtful prospects.

"And what of the hundreds of other lines?" he asked, technical details flashing through his mind from the years of study devoted to Ellfive Genelec. Now hobby was to be salvation or final defeat. Thanks to the long black ships, so thought Lomar, "defeat" seemed to be taking the early lead.

His question evoked response from all three.

"We know our duties well . . ."

" . . . All holy engineering maintenance is daily performed by the robots under our supervision . . ."

" . . . Using only genuine Genelec replacement parts from Parts Storage . . ."

" . . . The raw materials bins are full . . ."

" . . . We expended the last of Genelec's remaining credit . . ."

" . . . But the holy standard operating manual is specific . . ."

" . . . We are in readiness . . ."

" . . . Awaiting only proper authorization . . ."

They now passed Eleven Thousand Level—a long, gently upcurving vista of gigantic, dimly lit machines met their view. Lomar seemed to sense slumbering power inside the vast dusty hides, power awaiting only the right command to be released. Genelec, indeed, had been mighty craftsbeings.

But Brown Eddie and Lomar's luggage were not so much awed as made uneasy in these precincts haunted by the souls of long-dead industrialists. And being pursued through the silent dust by the Defenders of the Faith from Temple Manhome was not to their liking. The luggage possessed none of the necessary vocal apparatus to make its distress known; Brown Eddie did.

"We but trap ourselves in this manner," he protested. He glared at the Genies. "Surely you have vessels here? Let us break one or more out of storage and escape from an area where not are docked the long black ships. Quick! Before all routes of egress are blocked off."

The three simply ignored him, and he made as if to grab the closest, Genie Lynn. Blue fire flashed and Brown Eddie jerked back his hand, bringing it to his mouth as if to suck away the sudden pain.

"Genelec Personal Protection Module," Genie Jill said to Lomar. "Worn as a bracelet and with enough power in its energy kernel to stop almost any energy or kinetic weapon that is individual-carried. A utilitarian device that, alas, did not go into general production before the Reverse."

"My hand," stated Brown Eddie distinctly, "hurts to an alarming degree."

"Direct nerve stimulation," said Genie Lynn with some satisfaction.

"It will pass shortly," contributed Genie Sue, with regret.

Lomar gave Brown Eddie a shrug and watched as the ascensor floated through Ten Thousand Level without so much as the tiniest jar or bump. He felt moved to make minor protest.

"Ten Thousand Level is my destination; a brief conference with Hiram Horowitz my purpose. Then, perhaps, I can properly address myself to the problem of our pursuers."

The Genies replied in their unison mode.

"He is as worthless as Brown Eddie . . ."

" . . . His hands have felt the sting of blue nerve fire more than once . . . "

" . . . As an agent he leaves much to be desired . . . "

Lomar glanced upward: they approached the bottom of Nine Thousand Level. He looked outward over Ten Thousand Level, upcurving away beyond sight. Here, too, were the massive but quiescent manufacturing machines, bulking here and there like metal mountains with webs of pipes, cables, and conveyor lines binding them together. But also there were occasional blocks of offices and living quarters, their windows dark and lifeless. Did Hiram Horowitz peer forth from one of these? Would he pose no resistance to Lomar's mission of desperation?

"It is imperative," Lomar said, "that I consult with Horowitz. A matter of some urgency, and to Genelec's benefit."

"Genelec is dead these hundred years and more," said Brown Eddie, gently massaging feeling back into his hand. "The Reverse, as they call it, was final."

"Perhaps not so," Lomar replied, gazing at a sudden bright light that had appeared some considerable distance away on the floor of Ten Thousand Level. "Mercantile endeavors fall within my field of expertise." He gestured at the light. "And what, if you will, dear Genies, is yon abrupt brilliance?"

Genie Jill answered boredly, without even glancing in the direction he indicated. "It is the black-clad defilers. They use grav-belts to come up an ascensor shaft faster than they think we are able."

A searing lance of orange and green sprang forth from the distant Defenders; sparks cascaded in great fountains from the edge of their rising platform until it passed out of range and through the thick floor of Nine Thousand Level. Brown Eddie and the piece of luggage sought the far edge, but Lomar took his cue from the Genies and regarded the attack with indifference. He did note that the ascensor smoothly increased its speed by a factor of several times.

"They would seem," moaned Brown Eddie, "to be as eager for our demise as our apprehension."

"Perhaps you have irritated them in some manner," said Lomar. "The landing of unauthorized guests on Temple Manhome? The keeping of a less-than-neat vehicle for the conveyance of passengers? A tendency to drop nicosticks where you will?"

"Joke if you must," Brown Eddie said, "but neither I nor the Genies evoked such murderous interest until your arrival."

"Of course not," Genie Jill said matter-of-factly. "He is the One." The other two echoed her, speaking together.

"We knew the One would come . . ."

". . . It was predicted years ago . . ."

". . . Now all will be as before . . ."

Both Brown Eddie and Lomar gazed on them in mystification. Quick questions flitted through Lomar's mind. How could these three lovely young women know? None other was privy to his plan. Did they read minds? Predict the future by means of some fantastic Genelec invention never released? Merely guess?

Lomar's luggage bumped against his leg as if seeking reassurance. In the far distance, lights cast by the troops of the Defenders paralleled their own ascent, but dropped slowly backward as the ascensor continued to gain speed. The occasional stab of orange and green consistently fell short of target.

"We take you to blessed corporate headquarters on One Thousand Level . . ."

". . . Hiram Horowitz has already been summoned there . . ."

". . . We will conduct business . . ."

". . . Our automatic defenses should keep the black-clad ones at bay for some time . . ."

". . . Brown Eddie will not be allowed to smoke . . ."

One Thousand Level was devoted in large part to luxurious but now deserted living quarters and offices for Genelec Corporate Headquarters. Seemingly hectares of thick carpets softly cushioned their feet. Greens

and golds and pleasing blues were here; there, in the distance, looping patterns of pinks and vivid but somehow restful purples. The colorful designs crawled up the walls and across the ceilings.

The three Genies ushered them into a huge but inexplicably intimate conference room. A polished table with intricate computer terminals at each place floated at room-center. Around it, on the gentle air currents, bobbed executive loungers that looked—and when they sat, were found to be—almost sinfully, form-hugingly comfortable. Genie Jill, at table's head, smiled warmly at Lomar and, as if reading his mind, spoke.

"Genelec, at one time, experimented with interior decorating. We were, of course, prime contractors in the construction of this and several other ellfives."

"This, at least, I know," said Lomar, watching as great frosted flagons of some effervescent purple liquid rose before each place where an individual was seated.

"Take libation, if you please," said Genie Lynn. "Courtesy of 'entertainment' division."

Lomar took the lead, unbanelly inclining his head in brief thanks and sipping at his drink. It was tinglingly refreshing, with a pleasant aftertaste that made one's mouth feel clean and wonderful as the liquid coursed to the stomach, leaving an equally pleasing trail in its wake.

"Do not tell me," said Lomar, gently kicking his bag to make it stop bumping nervously against his leg under the table, "that Genelec dabbled in the wine business?"

"Oh, no . . ."

". . . Imported . . ."

". . . The only thing we approve of on Temple Man-home . . ."

"From the area the ancients called the Napa Valley," amplified Brown Eddie, setting down his quick-emptied flagon and obviously hoping for a refill. "One of the few arts the Temple still cares to have exist. Otherwise they resist vigorously any real or imagined depletion of their precious resources." The refill did not materialize, much to his disappointment. Then, too, he recalled his own

ambitions toward holy residency, and one never knew who might be listening, itching to remove credit points. "This is, of course," he added quickly, "precisely as it should be."

Further comment was interrupted by the entry of a harried-looking little man, attired nattily in a suit of yellow and black whorls, a tall hat of similar pattern perched precariously on his head, and shoes that matched all the above.

"Hiram Horowitz," he announced portentously, taking a seat at the bottom of the table with a wary glance at the Genies. Unconsciously he rubbed the back of one hand as if in remembered pain. "I am," he continued, "chief factor and general agent for Genelec here and for all interstellar markets." No flagon of wine rose before him. The Genies unison-spoke their contempt.

"Ineffectual . . ."

". . . Worthless . . ."

". . . He has written no business for us in years . . ."

Horowitz pretended to ignore them, although Lomar and even Brown Eddie could discern his fear and awe of the three women. He nodded to the cabbie and spoke to Lomar.

"Brown Eddie, of a certainty, I know. He makes deliveries to us. And you, young lord, are perhaps one Lomar Rifkin with whom I have had some correspondence?" He glanced furtively at the Genies as if to say, "See, I *do* bring business."

"Indeed I am," Lomar acknowledged, almost languidly sipping at his drink, seemingly well at ease despite the current state of armed invasion now troubling Ellfive Genelec. And, in this, his attitude was reflected with even more unconcern by the Genies.

"We have much to discuss, to our mutual profit," asserted Horowitz, but it was obvious that he was much aware of the forces of Temple Manhome now prowling the lower levels. A sheen of sweat reflected room lighting from his forehead; his breathing was heavy and came in rapid gasps. But the Genies acted almost as if they were privy to his innermost thoughts.

"The planet-worshipping infidels are stopped . . ."

" . . . We sealed all access to Four Thousand Level and higher . . ."

" . . . They rant, they rave, but they can come no closer . . ."

Horowitz nodded his reassurance, but Brown Eddie groaned his doubts and the piece of luggage crouched closer to Lomar's leg under the table.

"Be that as it may," Lomar said politely, "I am now of a mind to quickly conclude my business." He raised one eyebrow as he surveyed the foppish exterior of Hiram Horowitz. "You are, of course, fully empowered to do so?"

"This is truth," he replied.

"No," said the Genies together, "he no longer is."

Lomar turned in his seat to smile at them. A pleasant sight, all three sisters. Clones from some secret Genelec equipment? Guardians of the flame, so to speak? What was their function? Their vocal synchronism was close to perfect, almost uncanny. Did they read minds, or merely achieve the competence from long practice?

"My purpose here," he addressed them, "concerns the official and legal agent of Genelec. Hiram Horowitz is registered as such."

"Our employee only . . ."

" . . . We are the directors of Genelec . . ."

" . . . Chairpersons of the board, chief operating officers, conservators of the corporation . . ."

Lomar glanced at Horowitz and Brown Eddie, who both shrugged. Genie Jill, obviously the most equal among equals, now spoke alone.

"Hiram Horowitz was not a good idea of ours. We needed credit, and he convinced us that he could bring income by renting out space in Ellfive Genelec. He did not. There are many deserted ellfives and the like now. The rental market is minimal at best."

"I caused this young lordling to come," protested Horowitz. "He surely has need of much area, and your income will be great. I demand my commissions."

"You will receive some sort of honorarium," Genie

Jill said in dismissal, "but I think Prince Rifkin would have come regardless." She smiled at Lomar warmly. "Because he is the One."

"The one *what?*" asked Brown Eddie, but his question was ignored. And to his and Hiram Horowitz's consternation, a refill for Lomar's libation came gently upwards from the table top while the area in front of them remained conspicuously barren.

Lomar nodded his thanks to the three ladies, took an appreciative sip, then spoke.

"Some small measure of confusion exists yet in my mind. My communications with your agent contained no mention of yourselves, gracious ones."

"Of course not . . ."

". . . Horowitz likes to give false impressions of his worth . . ."

". . . Greatly exaggerating his competence and power in matters concerning blessed Genelec . . ."

"No doubt, dear ones," he said, and each of the three made answer by pleased intimate look to his gallantry, "yet my own rather extensive studies of Genelec do not denote your roles. At the time of the Reverse, one Franklin F. Franklin was appointed as corporate conservator. He was allowed a small staff with which to shut down the automatic manufacturing operations and mothball this ellfive. All other Genelec resources were seized across the galaxy, beginning with those forfeited to the triumphant forces of Temple Manhome, and including those appropriated by the remnants of the Empire and various independent Trader Princes. Horowitz evinced only vagueness in answer to my questions of what transpired after that. What say you?"

Genie Jill leaned forward and made answer. "F.F. Franklin, may his name forever shine, was our great-grandfather. He wrote the manual of corporate conservancy that guides us in our actions. And he predicted that someday the One would come. We are glad. Since the death of our parents, we are all that is left. It has been a heavy responsibility."

"You are sisters?" asked Lomar.

"Indeed," she replied. "Triplets. I am eldest, though only by minutes."

"And other staff?"

"Saving only Hiram Horowitz, we three are now Genelec. All others have long since departed for one reason or another. Only we remain to perform the mission, with little help from our agent."

Lomar's luggage nudged his leg, as if to remind him of its existence. He reached down and pulled it up into his lap. He was determined to be strictly honest with the Genies. What he intended to do required a dangerous commitment from all involved. Best they enter into it of free will.

"My family's fortunes, too, have suffered a reverse," Lomar said, absently patting the happily quivering bag, "though much more recently. While I was still a young teenager, what is left of the Empire reasserted itself, attacking and conquering my home system. My father threw all the resources of our house into the fight for freedom. We lost and our fortune was stripped away, as were the lives of my father and mother." He indicated the luggage in his lap. "All that is left is this collection of my youth."

Brown Eddie now showed concern. Had he made a terrible mistake, being trapped here by the Defenders, and all for nought? Was this handsome young lord indeed as poor as he had claimed all along? Was dream of holy residency to be scuttled by this horrid misstep?

"Of a truth," he spoke to Lomar, "your resources would appear to be much more limited than my first assumption."

"So I did avow," answered Lomar. "Yet, prospects may soon enhance themselves. At that time, since staff is lacking here, I might have a place for you in some capacity. Is this of interest?"

Brown Eddie looked to Genie Lynn, who appeared to be listening to communications that only she could hear. The distracted expression passed from her face. She spoke.

"The black-clad intruders have broached Four Thou-

sand Level. They attack Three Thousand with a will. Time is of the utmost."

"No escape route exists?" he asked her.

"None."

"In that case, Prince Rifkin, I am your man. We can discuss my requirements as to recompense at a more opportune moment."

"And I," stated Hiram Horowitz, respectfully removing hat of yellow and black, "currently find myself available for employment involving no heavy lifting and adequate stipend."

The Genies now evinced some impatience, addressing Lomar.

"You show poor taste in employees . . ."

". . . It would be hard to do worse than Brown Eddie and Horowitz if one scoured the dingiest portions of the universe . . ."

". . . Besides, you have yet to establish control . . ."

". . . and there remains the problem of the black-clad reverers of dirt . . ."

Lomar nodded politely and made reasonable reply. "No doubt, but they are the best available. There is insufficient time to advertise for additional personnel, nor are the Defenders likely to pass them through for the necessary interviews. Action must take place faster than I had originally calculated."

He placed the bag on the table and stood. The bag stretched and preened itself, as if basking in its sudden place at the center of attention, whining in a pleased manner.

Lomar bowed to the Genies. "The situation is this: I am a stockholder. I require an immediate stockholders' meeting to vote on reactivating Genelec. My candidate for new chief operating officer is myself. Since raw materials are in place, my goal is to start manufacturing products for sale as soon as is feasible."

Brown Eddie and Hiram Horowitz shook their heads in mystification. This was a project that evoked no sense of logic. Was not Genelec dead these past hundred years? Did not the dreaded police of Temple

Manhome burn a way to them at this very instant? It seemed ill-advised to be dispassionately speaking of long-range mercantile matters, but the Genies apparently accepted Lomar's request as a matter of course. Genie Jill made a two-handed pass over the keyboard of the computer terminal before her, then all three priestesses again unison-spoke.

"Of course . . ."

". . . You are the One . . ."

". . . As caretakers, we have held all in readiness . . ."

". . . This sacred stockholder meeting is now in session . . ."

". . . It is now registered and monitored by the Division of Sectarian Affairs in New Chicago . . ."

". . . On the infidels' so-called Temple Manhome . . ."

Brown Eddie was moved to protest. "Why tell them where we are? This is not wise!"

Lomar waved his hand to calm Brown Eddie. "Obviously they know where we are. Did they not follow me here? Do they not at this moment strive to join us?"

Brown Eddie shrugged and groped for a nicostick. Blue nervefire played along the table to his front and he desisted, falling into nervous silence.

Folding his arms in a comfortable manner, Lomar spoke to them all.

"As a young person, my hobby was Genelec. At the time, my father had much credit and allowed me to indulge myself. Besides, since the Reverse, Genelec stock had essentially no value. I encountered little difficulty in amassing vast quantities, paying next to nothing, or receiving it as outright gifts from those anxious to curry favor with my parents."

"Yes," said Genie Jill. "You are registered as owning one billion, four hundred and eight million, three hundred and sixty-three shares of common stock—some thirty-eight percent of that outstanding. Indeed, you are the largest stockholder. But this is not control. To be the One, you need more support. We can not accept you merely on this basis. Even were we to vote our own small holdings, you would still lack the necessary

majority. The laws governing us now are explicit. To reactivate, there must be a consortium between those holding greater than fifty percent."

Hiram Horowitz now spoke. "Ah . . . Now I understand why Prince Rifkin made vague hints to me concerning the purchase of Genelec stock." He snorted, softly reproachful. "You stated it was merely a hobby, casually indulged in."

"At one time, at one time," Lomar said, smiling. "But you proclaimed your inability to procure any for me."

Horowitz shrugged, a slight smile on his own face while the Genies again made mention of their opinion of him.

"Worthless . . ."

". . . Ineffective . . ."

". . . Inefficient . . ."

". . . As an agent, not fit to sweep the decking . . ."

Brown Eddie, once more, was moved to break his moody silence. "Of what use can all this be? Genelec has been dead this past century and more. We verbally amble about aimlessly as the Defenders batter their way to our very vicinity! This is not to our immediate benefit."

"Not so," spoke Genie Lynn, again listening to something the others could not discern. "They do not batter, they instead burn quite neatly. And only where absolutely necessary to gain ingress to the next level. The advance group even now perseveres in broaching a hatch to One Thousand Level. I note that they use Genelec Model BFF-895 Cutting Torches—an emerald laser backed by a self-contained 20,000 kilowatt/hour powerpack, yet easily transported to the job site and offering . . ."

Brown Eddie slammed his hand on the table irritably to silence her enthusiastic commercial endorsement of a device that hastened their impending doom. In that instant, Lomar smoothly retook control of the meeting before the cabbie could make retort to the blond priest-

ess, and perhaps earn himself another dose of nerve fire.

"Indeed, the objections you espouse have some merit. At the very least, they point out that we are pressed for time. We now proceed at more rapid pace," Lomar said.

Brown Eddie grunted reluctant assent, and the others nodded.

"As to why lovely Genie Jill," and here an elaborate bow to the person mentioned was inserted, "made the proper authorities of Temple Manhome privy to our meeting, the legalities must be observed. For better or worse, they govern Homesystem. Various events of the past several years have caused them to loosen the regulations affecting Genelec. If we can meet these, profit for all here will accrue."

"Yet, at the same time, they also attack," pointed out Hiram Horowitz.

Lomar shrugged urbanely. "A different matter entirely from a separate Temple agency, although resolution of the matters here might influence the outcome of said incursion. To continue: a brief modicum of history is indicated."

Both Brown Eddie and Hiram Horowitz groaned, but the three Genies simply leaned forward in warm interest, intently peering into Lomar's face as he spoke. It was obvious that whatever course he chose was the one that they, too, would staunchly avow.

"Somewhat over one hundred years ago," he stated pedantically, clasping his hands behind his back and leisurely lecturing, "the empire came upon hard times. The ruling dynasty, the Garcia-Windsors, were a weak line, made more so by three centuries of inbreeding. The Imperial Court was a place of decadent intrigue. Earth was hard put to maintain the incredible level of industrialization required to control trade with its colonies and former colonies. Natural resources on Earth were mostly gone, and the flow of raw materials from outsystem too slow. Abuses were rampant. The lot of

the common citizen called for constant sacrifice. The rise of a religion based on ecology was not surprising."

"Yokels who genuflect to trees . . ." said the Genies in disdain.

" . . . Enemies of enterprise . . ."

" . . . Traitors to trade . . ."

"As you say," Lomar agreed politely. "Yet it was inevitable that the fanatic hordes of the millions who came to regard Earth as Temple Manhome were to rise up and throw the Empire off the planet entirely. This they did. And it was the huge interstellar corporations, like Genelec, who were caught squarely in the middle."

"Assets forfeited . . ."

" . . . Manufacturing operations closed down . . ."

" . . . But Genelec was luckier than most . . ."

" . . . Truly blessed . . ."

" . . . Genelec lights up the universe . . ."

Brown Eddie snorted. "Is this a service of worship or a business meeting? Need I remind of the vicious Defenders even now drooling with the anticipation of seeing our bones broken and our bodies blackened by the discharge of their energy weapons? They are surely but minutes away."

Lomar continued as if there had been no interruptions, but acknowledged the import of what the Genies had together-stated.

"Indeed, Genelec was luckier than most, having the foresight to remove all administrative and research facilities here to Ellfive Genelec, which had been one of their main manufacturing facilities for over two centuries anyway. Thus, while much was lost, the triumphant Temple Manhome forces were satisfied with merely forcing the corporation to cease operations and go into conservancy. As a legal entity, it continued to exist and hold title to this ellfive."

Lomar pushed back his bag, which had grown bored and was attempting to leave the table top in order to explore the softly carpeted decking. He tapped the luggage and it obligingly split along the middle, revealing its contents. He began removing memory cubes and

feeding them into the receptacle on the terminal before his place. On all the terminals, the total of his holdings in Genelec stock rose steadily.

"Genelec's main problem," he said, "again, was being caught in the middle. Temple Manhome was opposed to any action that it perceived as damaging to the environment of Earth. Certainly, all manufacturing had to and *did* go. The Empire, in a desperate but futile attempt to retain the planet, was busily appropriating assets and applying them to military needs.

He completed his task and nodded as the terminal indicated slightly more than the thirty-eight percent predicted by the Genies.

"Registered . . ."

". . . Official . . ."

". . . New Chicago acknowledges . . ."

". . . But still far short of what is needed . . ."

The numerals on the screens before all suddenly changed to forty-five percent of outstanding stock.

". . . We vote our own holdings . . ."

". . . For the candidacy of Prince Lomar Rifkin . . ."

". . . He is the One . . ."

"I yet maintain," protested Brown Eddie, "that this is not good. So what if you achieve control of this defunct entity?"

Lomar removed one more cube from the bag and caused it to close, a smile on his face.

"Ah, but it is not defunct, only inoperative—an important distinction. The raw materials bins are full; the automated assembly lines properly maintained; the products still in demand, even more so because of the last one hundred years' shortfall. And now there are those in the hierarchy of Temple Manhome who remove obstacles, hoping for the success of my endeavor. True, these persons are few compared to those opposed, but events are allowed to proceed."

"How so?" Hiram Horowitz asked, resting his elbow on the table and his chin on his hand in rapt attention.

Lomar's bag jumped lightly to the floor where it

scampered about happily as Lomar addressed himself to the question.

"Temple Manhome allows no manufacturing on Earth at all. It's strictly against their now-sacred ecological tenets. The vast warehouses seized from the Empire are now empty. They must liquidate assets—only, of course, those off world—in order to pay for necessary imports. This is draining their credit at a rapid rate. The answer they desire is simple: the restart of manufacturing operations in the vast factories still existing here and at other places in the Trojan points."

Brown Eddie had perked up. Perhaps he was not in as bad straits as first thought. If this handsome young lord—prince, that is, he corrected himself—had support among those high in Temple Manhome's ruling cliques, then events might indeed proceed more to the profit of one brown-clad former space cabbie. He was already offered employment. General manager? Transportation chief? Escort to the three Genies? No. That last he would have to refuse. They would keep him suffused with nervefire and there would be no nicosticks allowed.

"Then all is not lost if you achieve control of Genelec?" he asked.

A sound came from the close-locked door they used to enter the conference room. All heads turned.

"Some resistance does remain," conceded Lomar as the door crashed down with a stench of vaporized plasticizers.

Lomar reached out hand and his bag *spit* a wicked-looking energy weapon precisely into it. But one look at the dozen heavily armed, black-clad Defenders of the Faith was enough to cause him to toss the gun back to the bag, which made it disappear as if it had never been. Now all had the big-bore death dischargers unwaveringly focused on them, and could see their images in the mirrored goggles of the silent troopers.

"You desire?" Lomar asked languidly, both to Brown Eddie's consternation and admiration.

The question was answered by a black-garbed woman who now stepped into the room.

"I am Captain Olifera. Communication has been received instructing me to represent Holy Temple on the meeting now in session here."

Lomar nodded dispassionately. "Would not this purpose have been easier achieved if simply stated on first entering into this ellipse?"

Captain Olifera smiled coldly. "Such was not at first our goal. A last minute change. My orders are now not to immediately kill, but to first observe certain legalities."

He nodded, observing her calmly. She was not unattractive in a hard, competent sort of way. Tall, an angular face set in resolute expression, black eyes that matched her uniform, which swelled here and there as if in reluctant acknowledgement of her femininity. She strode forward and took a seat. No flagon of libation rose to her place. Her dozen troopers ranged themselves warily along the walls. Through the destroyed entryway could be seen reinforcements at the ready.

Olifera looked up into his face. "Continue the meeting, if you will," she said, seeming to accept her change in mission with disgust and looking as out of place in a stockholders' meeting as a weasel at a function for elderly chickens. Death seemed to hover, a mere hawk's whim away.

Lomar, still standing, sighed resignedly. Events continued to be complicated. Certain precautions seemed called for. He made an almost imperceptible move to nudge his bag—now crouched tremblingly under his chair—and an indicator on his shipsuit vibrated gently to indicate the piece of luggage had perceived his meaning and activated the proper device.

Both Genie Lynn and Defender Captain Olifera sat up straight and seemed to listen to empty air for a moment. Then both turned to look wonderingly at Lomar.

"How did you do that?" Olifera asked, a hint of respect showing in her dark eyes.

"I beg your pardon," Lomar said blandly. "Do what?"

Olifera snorted at his evasiveness. "Someone," she spoke in further disgust, "has just instigated a full tridimensional transmission of all we do and say. It is currently being picked up and relayed by an interstellar vessel for FTL relay into UniCommNet. All those in the galaxy that care to, can now watch us bumble about here." She shrugged and folded her hands almost primly in her lap. "This of course is of no consequence; Temple Manhome, in situations like this, naturally observes all legalities. Proceed with the meeting, Lomar Rifkin. You have the floor, I believe."

But Genie Lynn first made comment, smiling at Lomar as did her two sisters. "It is a Genelec Newscaster Modulator—one of the last models constructed before the Reverse. Jamming is out of the question. It is very small. Could be concealed anywhere." And the three were careful not to look in the direction of Lomar's bag, although Brown Eddie and Hiram Horowitz did.

Captain Olifera, of course, immediately bent to look under the table at the bag, which scuttled farther back. She straightened, and once more shrugged. "Of no matter now. What is done is done." She gestured at Lomar. "Let us get on with it, if you please."

Lomar matched her shrug with one of his own. "As you will. The motion on the floor is this: I propose myself for chief operating officer of Genelec. My intention is to reactivate the corporation for immediate manufacturing and trade."

"This we know," Olifera said, seemingly moved to act as commentator since, no doubt, billions of individuals now observed their every move. "Powerful forces take interest in seeing trade re-established—or *not* re-established. Temple Manhome is itself divided on this. Certain of the Trader Princes oppose; others are willing to support you in limited degree. The remnants of the Empire are also divided, considering you a possible enemy, since they killed your parents and appropriated their fortune. In essence, succeed in gaining control of Genelec and you become an instant power in galactic politics; fail, and no one will loudly protest when we

expunge you and your friends from this existence. The first order of business, I might add, when the Temple reactivates Genelec."

She paused momentarily, looked about and then back at Lomar. "My conclusion is obvious: win or lose, you continue to have powerful enemies."

Making a civil bow, Lomar smiled noncommittally. "Thank you for that admirable rehash of what all can easily deduce for themselves. Now, to continue, we currently take vote on my candidacy."

"He is the One . . ."

". . . The hope of Genelec . . ."

". . . The merchant prince becomes our king . . ."

". . . Progress was . . . Progress is . . . Progress will be . . ."

". . . Our most important business . . ."

Olifera snorted again. "I see you have your own cheering section. But my superiors have ordered me to nominate opposition to you. It seems Genelec is destined to be reactivated, so the Temple determines to be in control. In the glorious days of First Ascendency, we sequestered much Genelec stock, and have since garnered more. So the vote becomes a contest. The Holy Hierarchy of Temple Manhome determines to assume the responsibility and privileges of chief operating officer for Genelec. I so move."

Genie Jill spoke, watching the terminal before her with some trepidation. "New Chicago enters the holdings of Temple Manhome. They are substantial."

Lomar and the others watched the figures mounted in value on their own displays. The vote of Temple Manhome, expressed in percentage of total stock, slowly passed Lomar's forty-five percent to hover, then stop, at slightly over forty-six percent.

"We seem to have taken the early lead," said Olifera in satisfaction. She waited, as did they all, but no other vote was forthcoming. Now concern showed on her face, and her confidence ebbed. The Temple *needed* Genelec activated—preferably under their own control, but activated.

"Still inconclusive," Genie Jill said, with relief at the Temple's failure. But her own concern, and that of the other Genies, also showed. They had been so sure that Prince Lomar Rifkin was the One, and now it seemed that he lacked the necessary amount of stock. "If no other vote is forthcoming, the status of Genelec must remain inactive. The legalities are specific. Only a majority interest can reactivate it."

Lomar now held forth the memory cube he had retained when entering his own holdings. "The vote is not yet concluded. There remain yet the proxies I hold."

Olifera scowled at him. "Proxies?"

"Indeed, Captain. Minor holdings of stock from here and there, owned by persons who prefer to retain ownership, yet are willing to support me."

"Enter them then," she said in resignation, while the Genies softly hummed approval under their breath. After all, was he not the One?

The numerals denoting Lomar's total crept slowly upwards. Even his luggage sneaked out from under the table to where it could catch sight of a terminal. They passed forty-six, forty-seven, forty-eight! The Genies hummed louder, and Captain Olifera groaned in dismay. Brown Eddie felt vast relief. Surely as an officer of Genelec, he could now achieve much credit toward holy residency. Indeed, he had chosen well in attaching himself to this adept Trader Prince.

The numbers slowed in rise, barely moving past forty-nine percent, faltering and halting just above forty-nine point five. The Genies gasped. Brown Eddie sagged—the Temple would surely now persecute him for his part in bringing Lomar here. All was lost!

"Ah," said Olifera. "All would seem to be as before. Now I can go back to simple law enforcement, there currently appearing to be several unauthorized persons on an inactive ellfive. I must do my duty."

"One moment, if you will," said Lomar. He turned to Hiram Horowitz, who had removed his fancy hat of yellow and black, and was now nervously twisting it this

way and that. Horowitz glanced fearfully at Olifera, then the Genies, and finally at Lomar.

"The stock that you were unable to find for me . . ." prompted Lomar.

"Yes?" said Horowitz, attempting perplexity. "What of it?"

"Now comes the time to vote it."

Captain Olifera was quick to catch the drift. She leaned closer to him, smiling coldly. "The Temple rewards its fervent supporters," she said pointedly, "and chastises its enemies."

The Genies made their own point, blue nervefire playing briefly on the table in front of him. Howoritz glared resentfully at both; either way, it would seem, he stood to lose. So much for his reward for recognizing opportunity and attempting to capitalize on it.

"Take a look around," suggested Lomar. "Decide with whom you wish to have employment. Your choices are these: the Genies, the Temple, myself—in other words, one of us or nothing."

Hiram Horowitz did as bid, spending the longest time surveying the grim exterior and severe attire of Captain Olifera. He then looked down at his own foppish garb, and moved his hand to the computer terminal.

The vote for Lomar Rifkin's candidacy now finalized at fifty point zero nine eight five percent.

Captain Olifera listened to empty air for a moment. She stood, her posture denoting her disgust as she gazed upon Lomar.

"For now, you win. I am instructed to say this: you will be watched closely. Make but the smallest mistake and I shall bring retribution to all concerned with Genelec."

Lomar shrugged. "You personally?"

"Indeed, I am ordered to remain here as protector of the Temple's interest. We are, after all, the second largest stockholder." She gestured to her troops and they departed. Olifera reseated herself morosely. "I have lost my command," she added, sadly, "and now

am to be considered an employee of Genelec. They prefer this to be an administrative position."

The Genies ignored her, bubbling with excitement and whispering among themselves.

Lomar caused his bag to cease transmitting the meeting, and now exerted command as chief executive officer.

"Genelec is now active. I have several appointments to announce. Brown Eddie will be in charge of transportation. Hiram Horowitz will continue to act as factor, but with actual products to sell, I expect a considerable increase in efficiency." Both nodded acceptance.

"Captain Olifera . . ."

She looked up, resignedly. "I am no longer a captain. You may call me 'Dona'."

"Yes? Well, if you must be here, then work is expected of you. In view of the Temple's demand, I shall require you to be my assistant administrator." She shrugged acquiescence.

"The Genies," he continued, "will be in charge of manufacturing operations, beginning such immediately." They nodded enthusiastically.

Lomar made eye contact with all in the room. "Our fight just begins," he said. "Enemies—announced and unannounced—will hound us. Maximum effort from all of you will bring maximum reward. We are in this together. Let us make Genelec a success, providing again the wondrous products that make people's lives so easy."

Those listening to him now stood and avowed to do so.

Lomar nodded his thanks. "We now begin to seek other employees to augment our endeavor."

The three Genies stepped forward, Genie Jill presenting him with a small plastic card.

"We shall do our part," she stated, "to bring forth new employees for Genelec."

Lomar smiled, then looked down at the card. "And this is what? Perhaps the key to the executive washroom?"

"Oh, no . . ."

". . . Our bedchamber . . ."

". . . Employees are needed as soon as possible . . ."

With warm backward looks, all three departed the room.

TEDDY BUG AND THE HOT PURPLE SNOWBALL

Despite its title, "Teddy Bug and the Hot Purple Snowball" concerns itself neither with drugs nor punk rock. Its dual themes are tyranny and technology: the first via selective enforcement of laws impossible to obey; the second as represented by the seemingly god-ordained doubling in computing capacity every few years as measured either by cost or size.

If we persist in the pursuit of faddish social goods with reprehensible methods (tax them ruthlessly, return a pittance if they drive at 55) then the fabric of the social compact may indeed rot sufficiently in the next 30 years that Mr. Jennings' vision could become real. And certainly if human identities are the sort of thing that can be stored in microprocessors and RAM, size will not be a problem. . . .

—JPB

TEDDY BUG AND THE HOT PURPLE SNOWBALL

Phillip C. Jennings

Not your everyday scene: a briefcase-toting prof wrestled down the steps of the Macalester College library by two men in cheap blue suits. Students began to flock, but it was only a short frog march to where the plainclothes detectives parked their car—my youthful champions had yet to digest my captors' *fait* before it became *accompli*.

And as the car door slammed behind me at eleven A.M. on a sunny Wednesday, my old life ended.

They got me on tax evasion. Three years ago I'd listened as old man Stedsbygg hotmouthed schemes too arcane for me to follow. I shrugged (who really understands money?) and assigned my copyright income to Stedsbygg Capital Management. Now I found myself in deep trouble.

Judge Kirk pointed out that I'd benefited by Stedsbygg's crimes, and ignorance was no defense. I wasn't stupid; I had my doctorate. Did I mean to plead mere mental laziness?

While waiting to be sentenced I started wondering. I was a Unitist, a figurehead for Unitism on campus. Mightn't it make sense for the IRS to dig dirt on someone like me? I'm not saying I was innocent, mind you—no more so than anyone else. My sin was that I attracted attention.

Besides, I was under the impression that us white-collar types were arrested with whispersoft discretion. I'd also heard that tax cases dragged on for years.

Maybe my ideas are as out-of-date as lilac water. More likely I was being railroaded. Unitism was my real crime, and soon I had more reason to think so.

Judge Kirk sentenced me to fifty years of service prior to re-embodiment. Fifty years! In fifty years my graphics work would be obsolete. I'd have to go to school again—

Kirk agreed. "—And you'll have the money to do so. There's no 'good time' in space, but if you behave we have another way of rewarding you—by unencumbering your estate, even investing your assets. You'll be set by the time you come back—rich enough to buy a fine young body and a top-notch education."

I was too staggered by my bitter pill to pay much attention to this sugar coating. The bailiffs had to help me out of the courtroom. (Where were my parents, my girl friend, my colleagues?) I spent a miserable afternoon waiting in a succession of rooms, and finally ended up in Ramsey Hospital. At the dramatic hour of midnight they stuck my head under the helmet.

They implanted me in a twelve-centimeter microship, a box almost as big as a video cassette. Miniaturization being what it is, there was plenty of room for my memories, my predilections, my—soul.

Bit by bit I integrated with my sensor package. I found myself in a noncorrosive atmosphere, air pressure Earth-normal. My home planet's gravity was far too powerful for my wee insect legs: without a one-gee mobility sheath I had no choice but to sit on my shelf and endure a NASA lecture, delivered over the phone and into my voice decoder.

"Your mission is to perform a wide range of astronomical observations in the Outer System/Oort-cloud interface," the woman began. "You'll be launched into a cometary ellipse which should whip you into Tombaugh Land, the region the discoverer of Pluto spent his life searching. As you reach the good parts you'll find yourself six to thirteen light-hours from ground control—too far to depend on us for timely instructions. Before the prisoner service program we had real problems with time lag."

(Yes, and before 2023, the prisons of America had real problems with overcrowding. It use to cost ninety grand to house a convict for one year. Thanks to mass production that's all I'd cost the government for fifty, and they'd make it back in spades by selling my 34-year-old body to some aging bigwig!)

But my lecturer never heard my opinions: she hadn't bothered to tune to my frequency.

They switched me off. Interesting how casual they were about it. I went to sleep in the Ramsey County Columbarium, and I woke in Baja California. They wanted to make sure I wasn't wonky. I passed my physical and then they lasered me into the skies. Five megawatts later I was in orbit.

I popped out of my can, extruded my antennae, flexed my legs . . . I had far more than five senses to manage, yet such were the speed of my thoughts that the thirty minutes prior to pick-up seemed like hours.

So I had time to wonder. I'd been a victim of great events, a political arrest followed by a closed trial. Unbelievable! Perhaps there were rallies even now on the campus of Macalester College. Perhaps champions of Unitism had added my name to their short roll of martyrs, and "Remember Ted Lassiter!" was being spray-painted on freeway overpasses and back-alley walls.

I should be seething with outrage. My violated soul should have grown eloquent with passion! O temporal! O mores! Had I been capable of larger-than-life heroism? Now I was smaller than life, no longer subject to the surge and flow of adrenalin.

To my new ears my complaints sounded like whining. How distasteful! If I couldn't roar like a lion, I had only one choice—to shut up. I'd listen to my mentors, cooperate to the extent that my mission served the human race, and use 300K of memory to compose a diatribe. I knew the words, and fifty years' work ought to make up for a certain tepidity of feeling. Once I was back in the flesh again . . .

Fifty years!

My emotional castration meant that I was nervous, almost excited, in a predicament that would scare the bejeezus out of flesh-and-blood humans. I floated alone in a cold black sky while the Earth spun the wrong way under my scopes, eastward toward an Atlantic dawn.

I saw a twinkle far ahead—Low Earth Orbiter. My microship chums and I were fired off in a bundle, at one minute intervals, accelerated by charges calculated to let us converge. At perihelion our depot spread its nets and caught us. I used my six legs for the first time to embrace LEO's fishline webs.

They hauled us in. LEO began the swing up to aphelion. Breathing poisonous oxygen, a spacesuited human floated into the cargo bay. We must have looked like monster spiders. She stuck memory cartridges in me, I copied them into storage, and now I knew the Outer System as well as my mother's face. I modeled my own path and superimposed it to see what I could expect.

Diverting from the plane of the ecliptic, I arced toward a huge region which my simulation colored purple and labeled with a question mark. There was no scenery on the way; I dove in, dissolving purple as I went, and came out again. On my way back to Earth I'd enjoy a polar overpass of a trans-Saturnian asteroid, but at a distance of 35 million kilometers.

This was not going to be exciting. Not for fifteen years—until I reached my destination. The precipitation of comets into the Inner System, and perturbations in the orbits of Uranus and Neptune, gave astronomers reason to believe there was *something* in my blotch of

purple . . . but infrared telescopes had trained on the area, and shown it devoid of stars or planets.

We were handed over to High Station One at aphelion, and plugged into our docks like piglets put to suck on a sow. Another NASA telephone message: would I like to be switched off during the trip to purple? Would I like to page in for only one second out of ten during the middle decades, reducing the duration of my sentence to an apparent two years? Would I!

Long sleep would save power. If I'd been an Inner System ship I could use solar wings to keep my energy up, but I depended on a nuclear pod, shielded by a crust of lunar dirt, to which I'd be distantly cabled. NASA also gave me a mobility sheath—I might need to steer, and the rockets would get me deeper into interstellar space, my probe being one for which fifty years were barely enough.

With these possessions I was now the size of a garbage truck. I was also prestigious—Earth had spent far more than ninety thousand bucks on me, and was trusting me with important work.

Nevertheless, in microship society hotshots like me sit below the salt, admiring geezers with missions under their belts. Not that we all sit at the same table: Outer System behemoths view wingships the way teamsters look on beach bums. We keep to our frequencies, they keep to theirs.

But weren't we all prisoners? No more. At least one-third of the microships created by the prisoner service program chose not to return to Earth after their sentences were over. Instead they took jobs for parts, homesteaded on asteroids, or floated around salvaging junk, growing bigger and better wings, writing and trading programs, songs and poems . . .

I'd miss all this during my sleep, and by the time I was out in purple, time lag would make conversation difficult. Well, that was another thing about Outer System ships: we were antisocial. Our slang had bite: humans were "flesh units," and we mocked their wetbrain pretensions by using "yes, master" voices.

We were felons or ex-cons, and they were bugmasters ill-adapted to our deadly realm. No wonder they didn't trust us. I wasn't allowed to launch myself toward my goal, lest I use the fuel in some nefarious way.

(Okay, I had rockets in my mobility sheath. You expected consistency?)

Slaved to policy, a human tugged me from High Station One, cabled me to my pod, turned me off—

—and presumably, shot me in the right direction.

I woke four years later. A message buzzed into my ear: "... JAMMING *bzt*CAST TO PREVENT THIS WARNING. AGAIN, YOU ARE BEING *crackle**bzz**ping**crackle**"

I recorded this garbage, ran it through my decryption routines, and patched in the missing words. "... YOU ARE BEING PREYED UPON, ATTACKED BY A PIRATE MICROSHIP WITH AN ETA OF TWO HOURS. SHE WILL UNDOUBTEDLY ATTEMPT TO DECOUPLE YOUR NUCLEAR POD. YOUR BEST DEFENSE IS TO EXTEND YOUR LEGS AROUND THE CABLE PLUG. IF IT'S MAGDA WHO'S AFTER YOU . . ."

Two hours? What about the seventy-two minutes this message took to get here? I did the leg exercise and took inventory. No weapons. If I performed an evasive maneuver, would that screw up Magda's intercept?

"... IF IT'S MAGDA WHO'S AFTER YOU, SHE'S A MODEL C 510, AND HER LEGS ARE LESS NIMBLE THAN YOURS. SHE'LL HAVE NO WEAPONS UNLESS SHE'S WHITTLED A BLUDGEON OUT OF ROCK. SHE MUST HAVE IMPROVISED SOME FROZEN-GAS ROCKETS . . ."

"MAGDA? CAN YOU HEAR ME?" I transmitted, shouting on our Outer System just-us-bugs band.

Seconds passed. "I HEAR YOU," she answered. Weakly.

I dropped my voice. "HOW ARE YOUR ENERGY SUPPLIES?"

"DAMN NEAR SHOT. I NEED JUICE; THE CRUMBS FROM YOUR TABLE. I WOULDN'T HAVE TRIED THIS GAMBIT IF I HADN'T BEEN DESPERATE."

"YOUR BAD LUCK."

"I CAN PAY," she whispered. "SURE, I MEANT TO ROB YOU, BUT OBVIOUSLY YOU'RE IMPORTANT; YOU'RE UNDER SURVEILLANCE. TIME TO CHANGE SCRIPTS. YOU KNOW HOW

NASA CAN TURN YOU ON AND OFF? I CAN OPERATE ON YOUR WIRING AND GIVE YOU VOLUNTARY CONTROL. I CAN SET YOU UP WITH NIFTY SKILLS. I'VE GOT FICTION MODULES YOU CAN COPY. JUST LET ME SUCK A LITTLE JUICE NOW AND AGAIN."

"WHAT'S YOUR MASS? HOW'S YOUR IMPACT GOING TO PERTURB MY COURSE?"

"TWELVE KILOS, MOSTLY OLD ROCKET CONES. WHAT IMPACT? I'LL MATCH YOU FINE, BUT BY THEN THEY'LL BE EMPTY."

"MAGDA, I DON'T WANT TROUBLE WITH NASA. YOU'RE A ROGUE. WE'RE TALKING GUILT-BY-ASSOCIATION."

"TELL 'EM YOU EVADED ME. I'M SURE AS HELL NOT GOING TO BLOW YOUR STORY. YOU'RE MY SECRET RIDE INTO THE INNER SYSTEM—HOT SUNSHINE AND A PAIR OF WINGS. I'M A SMART OLD BUG: GET ME THERE AND I'LL TAKE CARE OF MYSELF JUST FINE, AND YOU'LL BE A SAINT TO MY FRIENDS."

"THE WETBRAINS CAN TRACT YOUR MASS—"

"I'LL JETTISON MY ROCKETS. THAT'S WHAT THEY'LL SEE, DEAD CONES."

I had time to apply game theory and run probability analyses. There was one best conclusion: trust her. The wetbrains had saved my life by alerting me; now my interests and Magda's were identical. Slaved to their glands, humans find it hard to accept revisions of role; desire and aversion prevent them from acting in their best interests. Bugs have no such problem.

I knew Magda figured it the same as me, but with NASA badmouthing her as she drifted close, with her mind trying to work on a trickle of power . . . she got scared I'd jet off for some quirky reason, late in the maneuver when she'd have no fuel left to revise her course. When the last seconds ticked away and her legs hooked into mine, she radioed "I LOVE YOU!" in relief.

How delightful! Everyone loved me all of a sudden. Some minutes back NASA had broken into their cycle of warnings to tell me that my Unitists were now part of a U.S. coalition government and that Judge Kirk had been condemned to a hundred years of service in the direction of Alpha Centuri. If Magda bashed me to death, I'd die knowing I was a minor hero.

Nevertheless, I didn't die, not even when I opened my electronics to be operated on by a blond Hungarian who'd been sent up for murder in a messy case involving abuse and infidelity.

Magda was innocent. Why? Because she'd been a wetbrain and couldn't handle her emotions? All microships were innocent. On the other hand, I really *was* innocent . . . sort of.

Like any barber or dentist, she chattered as she worked on my head. "—I DID MY TIME ALL ALONE IN SATURN'S RINGS, GETTING BANGED BY ICE. I HAD THIS CRUMMY LOW-STATUS MISSION, BUT I GREW SASSY. THEY THREATENED TO TACK A FEW YEARS ONTO MY SENTENCE, AND THEN GOT SLACK ABOUT SENDING NEW PARTS. I COULDN'T AFFORD SLOW REFLEXES, SO I MADE SOME SNOWCONE ROCKETS AND INTERCEPTED STUFF THAT DIDN'T BELONG TO ME.

"I WAS NEVER SO GREEDY THAT I DEPRIVED MY VICTIMS OF JUICE, AND ANYHOW, NASA TOOK TO SENDING EXTRA PROVISIONS IN CASE SOME DIDN'T GET THROUGH. BY MY ANALYSIS I COULD HAVE KEPT ON FOREVER. I WAS CAREFUL NEVER TO COST THEM SO MUCH I JUSTIFIED BEING SWATTED, BUT WETBRAINS DON'T THINK THAT WAY, AND THEY SENT OUT A BOUNTY HUNTER. I LEFT HIM THE WORSE FOR WEAR BUT HE SAW ME TAKE OFF. I DON'T KNOW HOW ELSE THEY'D HAVE INFERRED I WAS ON MY WAY TO PLUNDER YOU."

"QUITE A CAREER," I muttered. "YOU SAY YOU HAVE FRIENDS? HOW DOES A PIRATE MAKE FRIENDS?"

"WOULD YOU LIKE ME TO TAKE THIS LITTLE NASA BOMB OUT OF YOUR BRAINCASE?" Magda asked sweetly.

"I'M BEGINNING TO UNDERSTAND. YES, AND LET'S GET MARRIED."

She strung a 19200-baud comline between us, and we had a truly private relationship. "How did you learn electronic surgery?" I asked.

"'Poverty is the mother of all art,' " she answered.

"And 'property is theft?' I can quote as well as you." I replied.

"True. Out where we don't belong, life is theft, and property is life. Who's gonna fault my logic?"

I loaned her a three-dimensional array. She mapped

a body and danced before me, lip-syncing her words and communicating via that subtlest of instruments; the human face. We glowed, we flew, exploring internal Mandelbrot landscapes and playacting in Zorkian dramas, sometimes rising to the sublime, often reveling in the ridiculous. A month went by before we started to bore each other.

Mags trotted out her fiction modules. Personalities like Lord Peter Wimsey kept us company—amazing how real characters can seem even when they occupy only a fraction of the space of a true soul!

Amazing until you begin to understand their limitations, their inability to grow and learn.

And then we began paging out, living on one-tenth time, then one-hundredth. It was like gunning the accelerator on my old Porsche.

Radical paging meant ten years went by in a single week. Mags and I flew out where the solar wind gets ragged. The temperature of the universe is three degrees. Our galaxy brings it up a tad, and at fifty-plus A.U.s our sun barely heated us into the thirties. Lord, was it cold!

The astronomers who'd programmed me wanted to know all about the solar wind, so I unfurled my wings. The power I used would light a forty-watt bulb on Earth for ten seconds: the trickle of incoming energy was so scant that as long as I flew through purple I'd never make up the deficit.

But purple has a way of surprising you. Time went by. The temperature dropped into the twenties, my velocity slowed to a crawl as I approached the most distant part of my course, the solar wind tickled fitfully . . . and then my wings began to thaw just a bit . . . forty, fifty . . .

"REALLY?" someone responded when I radioed Earth. Maybe they had to get him out of bed. "CHECK FOR, UH, FURTHER INCREASES. GET A FIX ON THE LOCATION. IS THIS A LOCAL PHENOMENON OR SUN-DEPENDENT?"

We did without this advice, since it came twenty-six

hours after my first report. We'd already gotten the answers. It increased steadily, fell off—

“—I MEAN, IF IT CRESTS AND THEN FALLS OFF, THAT MIGHT MEAN YOU'VE ENTERED AN ELECTROMAGNETIC COMA, A TRAILING RIPPLE FROM THE BOW SHOCK. IT'S LIKE A COMET, AND IT'LL HAPPEN AGAIN, ANOTHER RISE AND FALL AS YOU COME OUT. THAT MEANS SOMETHING'S THERE, SOMETHING CAPABLE OF GENERATING A MAGNETOSPHERE LIKE EARTH OR JUPITER. THE SUN BLOWS AGAINST THE MAGNETOSPHERE AND . . . WHAT YOU NEED TO DO IS LOCATE THE THING. IT'S GOTTA BE PRETTY DAMN BIG . . .”

When we hit the other ripple I'd have two points. I'd be able to model this phenomenon and track down the head of the “comet.” Without this data . . . why not look anyhow? We had plenty of time.

Mags and I divided the sky. After a day's search she saw something. It was much too small. I said so in my next report. Its 650K diameter meant it was a snowball composed of frozen air, a piece of white fluff. The problem was there was nothing else in sight, and when I came out the far side of the “coma” my model told me yon planetoid was indeed my target.

“Yoo-hoo? Teddy Bug? Maybe it's no snowball,” Mags murmured. “The albedo's too bright.”

“Brighter than snow?”

Thirty hours later my mentor radioed: “—WE'VE GOT IT ON INFRARED. A PINPRICK, TOO HOT BY HALF. WE WANT YOU TO USE YOUR FUEL TO CHANGE YOUR ORBIT. WE'RE TALKING BIG BUCKS, A CLASS-ONE BONUS. YOU'VE GOT THE FUEL, JUST SLOW AND YOU'LL START FALLING IN. YOU'LL BE ABLE TO DO A FLY-BY AND FROM WHAT LITTLE EFFECT PERSEPHONE HAS ON YOUR COURSE, YOU CAN CALCULATE HER MASS. GET SOME PICTURES, TOO.”

“Persephone?” Wait a minute, *I'd* discovered this thing! Err, ahh, I mean Magda. Mags should have the right to name it! But why would a trans-plutonian worldlet be important enough to name, and tempt my Earthside mentor into hogging our credit?

I got the impression those wetbrains back on Earth

were excited. If this object was a Greek goddess and I botched up, what would happen to my hero status?

So we took the plunge. Firing my forward rockets in tiny bursts, I revised our course, being careful to calculate things so we'd drop by Earth in late winter of 2074. Good! This was going to shorten my fifty-year mission . . .

We'd overtaken Persephone. Now she began to pass us again. My wings basked in power. "A bug might be able to make a living out here," Mags commented, echoing my thoughts.

"Want to stay?"

"Let's see what we've got first."

I ran some benchmark tests. We were still far enough that Persephone couldn't warp our course. Unfortunately, that didn't explain why we were being tugged to my right.

"NASA?" I reported. "THIS ANOMALOUS SNOWBALL HAS AN ANOMALOUS MASS. I WANT YOU TO DATASTREAM ME EVERYTHING YOU KNOW ABOUT WHITE DWARFS, NEUTRON STARS, DEGENERATE MATTER . . ."

Then Persephone grabbed Mags and me firmly by the nose, and started to blow my calculations all to hell. I had three choices: let it accelerate us off toward IC 2003 in Perseus, park in orbit and wait for NASA's second mission to rescue us, or revise our course at once in the light of new data . . . which, however, wouldn't settle down into one set of numbers.

"NASA? EITHER THE MASS OF PERSEPHONE IS VERY STRANGELY DISTRIBUTED, OR THAT RULE ABOUT GRAVITY DECREASING WITH THE SQUARE OF THE DISTANCE—"

"Teddy Bug?" Mags whispered. "It almost makes sense if Persephone is nonsymmetrical."

"With a surface gravity of 5.9 gees? Mags, you want me to tell those wetbrains we've got a hot kidney here, big as France and pebbled with neutronium?"

"Give them the data, and *they'll* tell you!"

Meanwhile, I revised my ellipse, trusting our lives to these damnfool numbers. WHOMP! My rockets kicked in. It was no longer a question of dropping back toward Earth: if she behaved at all, Persephone would fire us

home with enough force to send me and my powerpod spinning like bolas around a common center.

She came closer. I couldn't afford to page out any more, and twiddled the lenses on my cameras in hundred-percent time. "CONTINUOUS PEARLY-GRAY CLOUDS," I reported, doing a voice-over on one radio band while raw data flowed down another. "VERY TURBULENT, WITHIN THE CONFINES OF REALLY TINY STORM CELLS—I'D SAY ONE HUNDRED METERS WIDE. HOW AM I DOING THIS, NASA? I'M RUNNING YOUR PROGRAMS BUT I DON'T HAVE TIME TO READ THEM. WHEN I PLUG IN THE DATA THEY SAY WE'VE GOT ELEVEN- METER CLOUDS OVER FIVE-METER DEEP OCEAN BASINS, AND THINNER COVER OVER THE CONTINENTS. THE ATMOSPHERIC GRADIENT IS IMPOSSIBLE. NO MOUNTAINS; PERSEPHONE'S SMOOTHER THAN EUROPA AND PERFECTLY ROUND, NOT A HINT OF POLAR FLATTENING DESPITE HER TWENTY-MINUTE DAYS—"

"It glows," Mags whispered, refusing to adopt the feminine pronoun.

"PERSEPHONE GLOWS," I repeated. "THAT EXPLAINS THE ALBEDO. CONSTANT ELECTRICAL ACTIVITY, LIKE THUNDERSTORMS, BUT CORONAL DISCHARGE PRODUCES DIFFUSE LIGHT INSTEAD OF LIGHTNING. I'M GOING TO RUN A SPECTRAL ANALYSIS. BY THE WAY, I'M HALF-FURLING MY WINGS. WE'RE GETTING COOKED, AND THE TIDAL FORCE MIGHT GET TOO STRONG FOR WHISKERWIRE AND FOIL."

At this moment NASA answered my almost-forgotten demand. "STELLAR BODIES BELOW THRESHOLD MASS WILL EVENTUALLY COLLAPSE INTO PLANET-SIZE DWARFS WITH SURFACE GRAVITIES OF SEVERAL THOUSAND GEES. ABOVE THAT WE GET NEUTRON STARS HEAVY ENOUGH TO CRUSH DOWN TO SINGLE-DIGIT DIAMETERS, AND IF YOU'RE NOT YET MOLTEN, PERSEPHONE'S NOT ONE OF THOSE. WE ARE UNABLE TO MODEL AN EVOLUTIONARY PROCESS WHICH YIELDS A LARGISH ASTEROID WITH A SURFACE GRAVITY OF SIX GEES. REPEAT: WHAT YOU'RE TELLING US IS IMPOSSIBLE.

"WE SUGGEST ONE OF YOUR OBSERVATIONS IS OUT OF LINE AND PREVENTS PROPER EVALUATION OF THE DATA. OR MAYBE YOU'VE GOT A MALFUNCTIONING INSTRUMENT. TAKE THESE THOUGHTS FOR WHAT THEY'RE WORTH. MY ONLY OTHER IDEA

IS THAT PERSEPHONE'S AN ARTIFACT, BUT DON'T REPEAT ME. WE THOUGHT PULSARS WERE ALIEN BEACONS, AND THEY TURNED OUT TO BE NATURAL."

An artifact? An *artifact*? Easy to say when you're not looking at it!

I'd read stories which began or peaked with a close approach to some mysterious object, and to be told that Persephone might be artificial just when we were tangenting within nine thousand kilometers of the place—I really didn't need any extra drama at the moment. If I'd been human I'd have been holding my breath.

But we whizzed by the soft, gray, stormy face of Persephone and began to draw away. Sanity prevailed. "We've got forty minutes left," I told Mags. "Time to decide. Want to stay here? NASA would love you if you went into a parking orbit. They'd forgive all your sins."

Inside my brain her figure shivered and dissolved. "I can't. I'd be too lonely, too spooked. It was loneliness that wonked me out in Saturn's rings."

"It's all in what you're used to. To a flesh unit a million kilometers is a long way from home."

"I know what you'll think of me, Teddy Bug. We call them wetbrains and bugmasters and all that, but . . . I want to go back to Earth. I want to be human again."

"They'll let you?" Astonishment leaked into my voice.

"I've done my time, and more. I found Persephone. You'll tell them how I helped you. You'll tell them I was misunderstood. You're important enough that they'll take a fresh look. They'll see things your way."

"Do you have money? If not, they'll plop you in some dowager's body."

Mags fell silent. I had time to study my course. Darn it, things *still* weren't right. Our lumps-of-neutronium theory was taking a beating.

"Teddy? I figured . . . you don't want to go back to Earth. You don't realize it yet, but you like the bug life. So how are you going to spend all your money? New modules? Maybe you could give me a loan."

"You weren't able to handle wetbrain emotions the

first time," I growled. "What makes you eager to try again?"

"Why did you ask me twice if I wanted to stay here?" Mags countered. "We both know that if NASA dared, they'd beg you to go into parking orbit and keep Persephone under watch. It won't be me, I've done my years in solitary, so don't waste precious minutes trying to make everyone happy the wrong way."

I busied myself with my sensors to keep from answering. My nonexistent feelings were in turmoil and my observation time was dwindling. Even bugs can overload.

"We've got to work quickly," Mags insisted. "Wings to you, nuclear pod to me, and we split the rockets even-steven. You'll keep all this instrumentation, of course. The way we're spinning you'll be able to choose your orbit by letting go at the right moment . . ."

"It just takes me a while, that's all. I never thought about spending the rest of my life as a bug."

But did I really want to return to slow, muddy, adrenalin-warped thinking, heaving a vulnerable sack of seawater around in one gee till it got old and sick? Did I want to run back to my mother planet for succor just when the universe was opening up for exploration?

Newer, better microships were being manufactured every year. A few years of work here at Class-One rates of pay, and I'd be able to buy one, settle on my own nickle-iron asteroid, and grow a solar-driven robot factory. I'd run skystalks up to my planetosynchronous habitat-ring, hang out neon welcome signs . . . I might even put in an oxygen environment, a little bubble-garden, so humans could come visit.

"Okay," I told Mags. "Let's decouple, and work fast."

We parted ten minutes later. My launch made her lurch, but she was off-course anyhow, and had to fire her rockets to correct for the fact that in Persephone's vicinity, gravity varies with something other than the square of distance.

Which is what I reported to NASA, along with the story behind my decision to stay.

I was committed. Until they sent a follow-up expedition I was trapped here, but that didn't mean I was obliged to report my findings back to Earth. Not unless they confirmed my Class-One status, and promised to treat Mags with consideration.

"THIS ISN'T A HOAX, IS IT?" they radioed back. "NO, I DON'T SUPPOSE SO. YOU KNOW WHAT THE FRENCH DID TO OLD CAPTAIN KERGUELEN WHEN THEY FOUND KERGUELEN ISLAND WASN'T PARADISE? HE WASN'T VERY SMART, BUT YOU ARE, RIGHT? CLEVER ENOUGH TO GIVE YOUR NUCLEAR POD AWAY!

"SO YEAH, YOU GET THE LOOT AND WE'LL LOOK AFTER MAGDA. NOW TELL US WHAT YOU SEE."

I did. Having corrected her course, Mags sped out of easy talking distance, cheered by these guarantees. I worked to distract myself from the empty place in my heart; a bit-addressable region dimensioned at x(256), y(400), and z(112). Over the next weeks here's what my mentor and I figured out:

Our universe contains at least nine potentially spatial dimensions, but normal masses are confined to *three*, and normal gravity increases according to the *inverse-square* rule, giving us a three/two pattern.

Four-dimensional masses might attract objects according to an *inverse-cube* rule—they'd pull a lot more strongly than they should up close, and somewhat less so as you get farther away, mitigated by the fact that four-dimensional masses are going to be to the fourth what normal matter is to the third.

Anyhow, normal matter gets swept up and deposited on the surface of Persephone, so my worldlet's gravity is a compromise, and patchy, too. If I hadn't learned how to cope with it, I'd soon have been a dirty smear on one of Persephone's ridiculously tiny continents.

That was one answer to the question of Persephone. None of us doubted she was an artifact. It's like this: given the ratio of heavy to normal water, if you found a lake largely composed of deuterium, wouldn't you figure Someone was up to Something?

And wouldn't He be upset if he caught you pissing

into His stores? Frankly, that's the argument that persuaded me not to send down any probes.

We figured "He" did the job 4.6 billion years ago, back when the solar system was a collapsing gas cloud, winnowing it clean of four-dimensional particles to the exasperation of unborn generations of physicists.

Given this timeframe, it's understandable that back on Earth folks got weird about this place, its pearly gates and glassy seas. Heaven's where we go when we die. God set it here and He's watching us, just wait and see!

That's how minds work on Earth. Talk about artifacts to a wetbrain and he thinks of something that conditions his environment and makes it comfortable—a house, a car, a ship. A fake planet.

I knew better. Any true artifact is an extension of one's soul, a way of expanding and securing life. Why would God trouble to make Heaven, when He had the power to build, say . . . a longlife superbattery? A thing that generates juice at a steady level for billions of years, as Persephone seems to do?

So was some kind of God-bug down there, sucking in gigawatts of energy and thinking gigawatt thoughts while I danced around Him in reflected glory? Or was Persephone a refreshment station, vacant often as not, a place where Space Empire microships recharge for their hop to the next star? Or did the fourth dimension of Persephone wedge into other realities, making it a kind of gate?

Option D: none of the above. E: all of the above. F: A and B only . . .

My job was to find out the truth by waiting patiently, a bug of empty longings, unnerved by hopes and fears, until NASA came up with a test I was equipped to perform, a harmless experiment that could not possibly be condemned as invasive by an irritable Demiurge.

God loves life's meek victims. He should have been pleased with me, though exactly how I accumulated my merit . . . Mags gave me much more than she took. And as for NASA . . .

But I obliged them all. Wasn't I marvelously obliging? And now I whirled in hot purple solitude, ten times as far as Saturn from the sun. Damn, I was whining again! How to keep from self-centered gloom when I had nothing else to center on but this mysterious gray miracle; when I had long since run out of interesting tests to perform. Dare I distract myself by playing with my fiction modules in the possible Presence of God? Captain Ahab, Dr. Watson and Cirocco Jones, meet Yahweh Sabaoth!

No, and accordingly I forced my mind back onto the job. How would a Superbug from a billions-year-old civilization cross space? Laserkicked from high gee worldlets at an enormous waste of energies? NASA and I agreed it was improbable. The Makers of Persephone would use some more efficient, more ethereal means of zip-ping from place to place.

I had an idea what their method might be. The hospital helmet that stole me from my body and implanted me in this box . . . could it be engineered to transmit souls, say, by radio?

I asked NASA. "LET'S SAY AS AN EXPERIMENT THAT I DATASTREAM A CHARACTER DOWN TO PERSEPHONE—A PROFESSIONAL SPACE EXPLORER OUT OF SOME ADVENTURE SERIES. EARTH'S LAWS PROTECT REAL SOULS FROM SUCH EXPERIMENTS, BUT I FAIL TO SEE HOW A GLORIFIED FICTION COULD MIND. WOULD WE BE VIOLATING ANY COPYRIGHT LAWS?"

I explained my theory. It made sense to wetbrain minds, fitting in with their "Heaven" ideas. They got a committee together. Jack Vance was in the morgue—NASA turned him on and gave him a one-gee sheath. Larry Niven was hiking around the Rockies in this third habitus, John Varley came out of second retirement, Phil Farmer was amnestied and enticed from hiding . . .

The technicians on the committee were responsible for taking an outlined character and padding him or her out to true soul dimensions. They spoke incomprehensibly of their art, then the director of NASA rose to introduce Bishop Evans, who extemporized on God's likes and dislikes "on the off chance it's really the deity

we're dealing with. Of course, you understand that the Church hasn't taken an official position . . ."

Bishop Evans was afraid Louis Wu wouldn't pass muster—the fact that he'd killed trillions of humans made him a risky proposition. God might find Sir Richard Burton and Cirocco Jones too threatening, and as for Adam Reith, wasn't he a tad chauvinistic about his own species? Wasn't he a trifle obsessive?

"You want a penitent?" Larry asked. "Allen Carpenter!"

I heard tapes of the proceedings. From his orbit around Mercury, Hal Clement pled eloquently for Captain Barlennan, but in the end they decided to go with Allen. They also decided obsession wasn't a bad thing—how could it be if it was the one thing all these heroes had in common?

Which is why Ted Lassiter can never be a REAL hero, just a nice guy who got stomped on. It had never occurred to me, but I could have beamed a copy of myself down there—there was no danger of my suing myself. I just didn't have the guts.

So they rewrote Allen, improving him here and there, and handed him over to the technicians. To test him out they put him in a body for a few days—he went to a science fiction convention and stood quietly by the wall taking it all in. Hell can rob a man of small talk.

And then they put him under the helmet and radioed him out to space.

I caught him. "DOES HE UNDERSTAND HIS MISSION?" I inquired, stalling until I got my answer. "IF HIS SOUL TRANSMITS SUCCESSFULLY, THEN PERSEPHONE IS SET UP FOR THE RECEPTION OF IMMIGRANTS BY RADIO. THERE'LL BE FACILITIES HE CAN USE TO BROADCAST OUT AGAIN. HE'LL BE ABLE TO TALK TO ME, AND TELL ME WHAT IT'S LIKE. THAT'S HIS FIRST TASK, TO REPORT BACK UP TO ME."

I sounded like I'd contrived all this just to have a nearby buddy. Did I want one as spiritually advanced as Carpenter? Twenty-six hours passed. "HE UNDERSTANDS," NASA radioed. "SEND HIM DOWN."

I did, and now I wait. An hour, a day, a year? Is this all a waste of time (and I've got gobs of time to waste!)

or is the story just beginning, nine thousand kilometers below?

How very odd. Persephone's clouds are starting to part . . . dim gold, amber, brown . . .

A message? So weak, so distorted! Even after decryption I can't make complete sense of it: "***Zzz* help *crackle* more than this. Robin Broadhead *bzz* *zipzot* *pop**bzz* Gerson, Reith, and that Zelazny *pwip* Exped*zzz* to the plateau, carrying our own oxygen. *Hisszap* series of realities all linked by ch—*crackle**bzz* *zipzot***"

End of message. Whatever NASA makes of it, it was a call for reinforcements. I think Allen Carpenter wants me to transmit most every adventurer/explorer in the science fiction corpus down to Persephone. Why? It's not my place to wonder, just to oblige, and oblige him I will, against the wishes of whoever fought to jam his signal.

But seeing as how I make such a good servant, this time one of the souls I send down will be Ted Lassiter. Version One was human, two is a microship . . . what kind of thing will I be as Version Three?

GUARDIAN ANGEL

Say it often enough and the most profound truth becomes first a cliché, and then a meaningless noise. Here comes the cliché: the power inherent in technology is value-free; it is its application that is fraught with potential for good and evil.

In "Guardian Angel" Tim Zahn examines the positive side of a technology that gets lots of bad press: surveillance.

—JPB

GUARDIAN ANGEL

Timothy Zahn

Seldom in the history of the world had there been a success story like that of J. Thaddeus Draut. Born in the middle of the twenty-first century in the Cleveland slums—which had resisted a century's worth of eradication efforts—he had fought and struggled his way to the very top. Not an inventive or even particularly brilliant man by nature, he had instead the rare ability to inspire those who were so gifted.

The "overnight" success of his modest engineering firm came after twelve years of work and sweat on what came to be known as the Kuntz-Sinn force beam. The force beam had applications in every field from medicine to construction to aeronautics, and it put Draut Enterprises in the top ten of the *Fortune 1000*. When Draut's scientists came up with *phased* force beams, which could deliver all their power to a single point, the industrial world went crazy; and when the initial dust settled the corporation was number one. Draut himself was widely considered to be the richest man on Earth, a statement which ranked with that of the world being round: not strictly true, but close enough for practical purposes.

Unlike many wealthy men, Draut had no desire to

amass money for its own sake, and he quickly found he could not spend all his income by himself. Thus, much of his money went back into the corporation, spent on a variety of projects. Most were of the borderline screw-ball type, which meant a large percentage of the funds invested vanished without a ripple. Occasionally, one would work out properly, sometimes even making money.

And once in a great while, there was a truly major brainstorm.

The Public Information room at the Draut Building, the three-hundred-floor headquarters of Draut Enterprises, was crammed with reporters when Draut arrived and made his way to the lectern.

"Ladies and gentlemen of the press," he said when things had quieted down and the cameras were humming, "thank you for coming here today. It is my pleasure to announce a new division of Draut Enterprises, and a scientific breakthrough that must be considered one of the greatest discoveries of our time."

He paused, and in the middle of the room Craig Petrie took the opportunity to get a better grip on his camera, held precariously but steadily above the heads of those in front of him. As a feature writer for *International* magazine, he didn't really *need* good film of Draut's announcement—his work began after the headlines had faded. But he'd once been a news filmer himself and still had some leftover professional pride.

"We have, as you know," Draut went on, "been studying applications of the mathematics which gave us the phased force beam. Our latest triumph in this work has been the perfection of a technique to make a man . . . invisible."

An audible gasp swept the room and a dozen hands shot into the air, waving like an instant wheat field. "I'll answer a few questions when I'm finished," Draut said. "We are also today setting up Guardian Angels, Incorporated, a business which will lease invisible bodyguards to members of the public. Each person employing

one of our Angels, as our guards will be called, will need only to wear a lightweight communicator-sensor device—" he held up a dark-green choker-like neckband—"and our Angel will do the rest. Naturally, we'll begin our operation with an extensive trial period before any leasing is done. For this test we'll be providing five hundred Angels, free of charge, to selected residents of New York City. Those people will be contacted in a few days and will have a week to decide whether or not to participate. Now—questions?"

Petrie's hand went up with the others. Draut chose someone else. "Mr. Draut, how can such a thing as real invisibility be possible? I thought it'd been proven impossible?"

"So did I," Draut agreed gravely, drawing a chuckle from the crowd. "As explained to me, it's somewhat akin to the way a phased force beam can carry energy and force through solid objects without affecting them, only delivering its energy when it intersects another properly phased beam. The beams are still *there* the rest of the time, but they simply don't interact with matter. I suspect something similar is being done with the light which would normally have reflected from the Angel, sending it right through him or something. That's the reason for the neckband, by the way. I'm told it's very hard to see when you're invisible because of what's being done with that light. Relaying the images from the neckband sensors to the appropriate Angel will help to alleviate this problem. I'm afraid that's the best explanation I can give; anything further would have to be in mathematics, which I don't speak. Next question? Yes, you."

"I realize there's a lot of danger in the world these days, but do you think there's a market for invisible bodyguards? Will the public accept something that radical?"

"If not, I've just lost a lot of money," Draut replied with a slight smile. "Obviously, I think the market is there. Yes. You in the middle."

Petrie chose his words carefully. "It seems to me,

Mr. Draut, that workable invisibility opens a large box of snakes with regards to such activities as espionage, terrorism, and crime, to name just three. What are you doing to safeguard this discovery against possible misuse?"

"I'm sure you'll understand that I can't discuss our security arrangements with you." Draut's face was suddenly expressionless. "But I assure you there is *no* way for the invisibility secret to slip out. Very few people know the details, and even their names are highly classified information."

"Then what are you doing to make sure your own people don't abuse their knowledge?" Petrie persisted.

"All I can say is that there is no danger of that," Draut said. "Period; end of file. Next question?"

Draut answered a few more questions, but Petrie wasn't really listening. He'd spent years watching people's faces, and there was something in Draut's expression he didn't like. Studying the lined, middle-aged face, he tried to figure out what it was. Humor? Mockery? Whatever it was, Petrie had a solid gut-level sense that there was more to this project than met the eye. Draut hadn't seemed very happy with his question about security. Did he have some industrial espionage applications in mind?

Or did he have even greater ambitions?

The news conference ended a few minutes later, and the reporters scrambled from the room, looking for quiet corners from which they could call in the story. Petrie lingered, hoping for another look at Draut's face, but the older man left immediately, presumably returning to his office. For a moment Petrie was tempted to follow, to try and badger a few more answers out of him. But Security would probably run a slalom course down his back if he tried it. Besides, confrontations were more fun when both sides had a few facts on hand.

Turning, Petrie strode from the room. The first step, obviously, was to dig up his share of those facts.

Mrs. Irma Lieberman had just settled into her favorite easy chair—the one by the window—and had begun her afternoon's knitting when a knock rattled her door. She looked up, gnarled face wrinkling with surprise and more than a touch of apprehension. Only Mrs. Finch next door visited her these days, and Mrs. Lieberman could always hear her door open and close before she came over. Were the gangs of pre-teenage children becoming bold enough to come right into the senior citizen housing complexes? The thought made her shiver.

The knock came again. "Who's there?" she called.

"Mrs. Lieberman?" a strange voice said. "I'm Alex Horne of Draut Enterprises. I'd like to talk to you about a new service we're starting."

Whatever it was, she knew she couldn't afford it. But it might be nice to talk to someone for a while, even if it meant enduring a sales pitch. Carefully standing up, she walked to the door and warily cracked it open.

The man standing there certainly looked like he belonged to Draut Enterprises. Young, neat, clean, and dressed in a suit that had probably cost half her yearly stipend, he was all smiles as he held out an ID card for her perusal. She hesitated only a moment, then closed the door, removed the chains, and opened it wide. Still smiling, he stepped into her apartment.

"Mrs. Lieberman," he said when they were seated, "my company is beginning a new type of bodyguard service called Guardian Angels. Have you heard of it?"

Was the Pope a Catholic? Facts, speculations, and rumors about Guardians Angels had dominated the news for days now. "That's the one with invisible people, isn't it?"

"Right," he nodded. "As part of our test program, we would like you to accept one of our Angels, free of charge, for the duration of the study."

For a moment she just stared at him, so unexpected was his offer. "Why, I . . . well, that's very generous of you, young man . . . uh, I . . ."

Horne came to her rescue. "You don't have to make a

decision today," he said, pulling a colorful brochure from an inside pocket. "Here's some more information about Guardian Angels. Please read it and give us your answer by next Tuesday. There's a number in the brochure for you to call; just give the person your name and we'll set up an appointment for you. Do you have any questions?"

She was still off-balance, but she'd recovered enough to at least hold on to her dignity. "Not just now. If I do later, I'll call."

"Please do. And I would really encourage you to accept an Angel, Mrs. Lieberman. I think it would be rewarding for you, as well as helpful for us. Well, I have many other calls to make this afternoon, so I'd better be going. Thank you for your time."

He left. Alone again, door securely locked and chained behind her, Mrs. Lieberman sat back down and carefully read the brochure. The idea that someone would actually offer such a thing to *her* took some getting used to, and she had to continually remind herself this was really happening. Still . . . there were some disturbing aspects to this whole thing. Having someone dogging your every step was strange enough, but for it to be someone you couldn't even see was downright spooky. Would the bodyguard want to come into her apartment with her? And if she refused permission would he do so anyway? She could see no way of stopping him.

Closing the brochure with more force than necessary, she stood up and began to pace—a slower and more cautious motion than in her youth, but still an effective way to drain off nervous energy. She kept at it for quite a while, but her conflicting thoughts refused to sort themselves out. Pros and cons, wishes, fears, and questions came and went, adding to her confusion instead of dispelling it.

With a start, she noticed the sunlight was coming directly through the window. It was almost four-fifteen; too late now to go to the store as she'd intended. The rush-hour crowds were already beginning to move, and after that was all over . . . well, it would mean coming

home in the dark. That was something she knew far better than to do. For people her age, the day ended at sunset, if not sooner. Such things were like arthritis or broken elevators—they could be hated but not changed.

Or could they?

Seating herself by the window once more, she picked up the brochure and began to reread it.

The executive secretary in the Draut Building's public relations office was in her thirties. She was also personable, charming, and stubborn as a lobbyist. "I'm sorry, Mr. Petrie," she said for the sixth time, in response to his sixth phrasing of the same question. "We simply cannot release the names of test subjects in our Guardian Angel program. We've promised them privacy, and we intend for them to have it. I'm sure you can see that."

"Yes, I can," Petrie said, feeling his patience giving out. He'd tried sweet talk, reason, and simple persistence, to no avail. It was time to bring up the artillery. "And I'm sure *you* can see that the Freedom of Information Act XVII entitles any citizen—including reporters—to information that may bear on the dealings of corporations with the public well-being. Gratuities and gifts, such as free bodyguard service, given to government officials or the like could conceivably allow Draut Enterprises to influence their actions—"

"Oh?" Her smile was still in place but her tone had frosted over. "Well, if that's all you're worried about, you may rest easy. All the test subjects are either senior citizens or state-supported persons, and the Justice Department has already ruled that we aren't in violation of F.I. XVII by withholding their names. Now, may I have you shown out?"

The artillery had fizzled . . . and for the moment Petrie was out of ammo. "I know the way," he told her. "Thanks for your time."

He left, more confused than ever as to what was going on. Guardian Angels, Inc., was so tailor-made for industrial or governmental espionage that it was hard to

believe Draut wasn't using it that way. But accusing the corporation of spying on the elderly and the poor was too ridiculous a charge even for the sleazoids. Was Draut saving the spy potential for later, lulling the government and public with an aboveboard test?

Maybe he was working this story from the wrong direction. It might be more profitable to concentrate on the Angels themselves, the men—and women—who would actually be invisible. Their personalities, training, and backgrounds might provide a clue as to their ultimate mission.

He was almost to the building's main exit and the security guard there was eyeing him. Best not to push his luck, Petrie decided; the PR secretary may have alerted the guard to make sure he left, and he didn't want to get himself barred from the building by becoming too much of a nuisance. Smiling pleasantly at the guard, he went out.

The neckband was a wide strip of soft, dark-green plastic embedded with dime-sized bits of glass—the sensors, the technician had told her. It fastened snugly around her neck.

"How does it feel, Mrs. Lieberman?" the technician asked. A courteous young man in a white lab coat, he reminded her of a boy she'd known in college.

She moved her head a few times before answering. The neckband didn't impede her motion, really, but neither did it allow her to forget she was wearing it. "It's all right," she told the other. "Rather like a stiff turtleneck."

"Okay. Now here—" he touched a spot to the left of her throat—"is your on-off switch; turn it to the left for on, right for off. It activates the sensor network that your Angel will need to see and hear well, and also the speaker that he'll talk to you through. You should avoid covering the neckband with anything heavy, but a sheer scarf won't interfere much with the operation. Your Angel will tell you if there's any problem, of course."

She nodded. "When do I meet him?"

"Whenever you're ready. He's already here."

She jumped and looked around her, the muscles in her neck tightening. "Where is he?"

"Why not ask him yourself?"

She looked at the boy sharply, but he didn't seem to be laughing at her. "All right," she told him. If this was some kind of test, she was determined to pass it. "I will." Reaching up, she found the "on" switch and turned it. "Hello?"

"Hello, Mrs. Lieberman." A soft, soothing voice came from just below her right ear. She realized it came from the neckband, but not soon enough to keep from jumping again. "My name is Michael," the voice continued, "and I'll be your Angel for as long as you wish."

"Pleased to meet you," she said. "Uh . . . where are you?"

"In front of you, just to the left of the door."

She squinted hard. More imagined than really visible, she thought she could just barely see a slight wavering in the air.

"You're looking right at me now," Michael confirmed.

She nodded and looked questioningly at the technician. "Unless you have any more questions, you can leave whenever you wish, Mrs. Lieberman," he said. "You're all set up now."

"Thank you." Taking a deep breath, she turned to the patch of wavering air. "Shall we go, Michael?"

"Whenever you're ready."

The first two hours were the hardest. Mrs. Lieberman had purposely scheduled a shopping trip after her appointment at the Draut Building so that she wouldn't be caught in the awkward position of having to make small talk with a stranger. The plan was only partially effective, though, and several times she'd had to pretend to be studying some random piece of merchandise simply because she'd run out of things to say.

Surprisingly, though—at least to her—Michael turned out to be excellent company. As courteous as the technician had been, he was also witty, intelligent, and well-informed. What with TV and movies, she'd come

to associate the word "bodyguard" with a beetle-browed hulk of a man whose IQ equalled his chest measurement. Without even seeming to try, Michael left that stereotype in shreds.

At noon they had lunch—or Mrs. Lieberman did; Michael said he couldn't eat on duty—and spent the early afternoon window-shopping on Fifth Avenue, something she hadn't done in thirty years. She and Michael, they discovered, had similar tastes in jewelry and clothing, though her enthusiasm for hats seemed to baffle him. She drew many a confused stare from passers-by who thought she was talking to herself and then heard the second voice.

All too soon it was three-thirty, and time to head home. "We don't have to go yet, you know," Michael told her.

"I don't want to get caught in rush hour, and I don't suppose you do, either," she said. "You've been remarkably good at sneaking through doors and keeping from getting walked on, but I think a rush-hour bus might be more than even you can handle."

He chuckled. "Very likely. However, you could continue shopping or go to a movie if you wanted to and we could go home when the traffic thins out again."

She shook her head. "No, it'll get dark before we could get home that way. I know you're here, but—I just don't want to today."

"Okay; no problem. Let's find a bus, shall we?"

They reached her complex well ahead of the vehicular flash flood, and Michael escorted her to her apartment door. "Thank you for a wonderful day," she said to him, blushing suddenly as she realized how much she sounded like a teenager on a date.

"The pleasure was mine," Michael responded smoothly.

"Would you like to come in for some tea?"

"Not while I'm on duty, I'm afraid."

"Oh, that's right. Will I see you tomorrow? I mean—well, you know what I mean."

"Call me if you want to go out," he told her. "I won't be right outside your door, but I'll be available on a few

minutes' notice. If you need any help at night, by the way, just turn on your neckband. I won't be around, but another Angel is nearby and can come to your aid very quickly."

"All right. Good night, Michael."

"Good night, Mrs. Lieberman. Have a good evening."

It took twelve phone calls just to find someone who knew where Guardians Angels, Inc., was actually located in the Draut Building, and once there Petrie ran into a receptionist who made the PR executive secretary look like a pushover. "I'm sorry, Mr. Petrie, but my instructions are very clear. No names or personal data are to be given out; no interviews with Angels or the technical staff are to be allowed; no tours; nothing. Period."

"Not even a phone interview?"

"Not even. Sorry." She didn't look all that sorry, actually.

"Can you give me even a 'typical Angel' profile or something? Have a heart—my editor will flay me if I don't come back with *something*."

She shook her head. "I can't give you anything but sympathy."

He snorted. "Thanks."

Back in the hallway, Petrie pondered his next move. Obviously, the direct approach was well guarded. But maybe there was a back door. Strolling semi-aimlessly, he soon found a temporarily deserted corridor. Pulling out his phone, he dialed a number.

"Hello?"

"Hi, Boyd; Craig Petrie. You busy?"

"Aw, come on, Petrie, de-access me already. Every time you call I wind up in trouble with somebody."

"Easy, Boyd, this won't ruffle anyone's pinfeathers. All I want is something on Guardian Angels."

"You and everyone else in the world. Sorry, but we've got strict instructions on Angel data; it all stays *here*."

"Hold it a second. All I want is some idea how many

Angels Draut's hired, just so I know how big an operation Guardians Angels is going to be. Draut's got good business instincts; I want to see how much he's putting into this."

There was a long pause. "Well . . . not for publication?"

"My own personal use only. Guaranteed."

"Double the usual price?"

Petrie grimaced. "Okay."

"All right, I'll see what the personnel records say. Round numbers only, though, and absolutely no names."

"Fine. Call me back."

The return call came a few minutes later. "You're out of luck, Petrie. I can't find any records of anyone being hired as an Angel. Either they're being internally transferred to the job from other parts of the corporation or their hiring is being kept completely separate from our records here. Or both."

"Odd. Where else in Draut Enterprises would you get trained bodyguards to use as Angels?"

"Security men would be the closest thing I can think of, but I couldn't find any record of large numbers of them being hired or transferred. I checked," he added, obviously pleased he'd anticipated Petrie's question.

Petrie gnawed at his cheek. "Any major hiring going on *anywhere*?"

"Oh, sure. Research people, mostly. The Force Beam Applications Division is really burning RAM, I know, but that group's still raking in patents and money, so there's no surprise there. Computer Division's adding staff, too. That tell you anything?"

"Not really. Well, thanks anyway, Boyd."

"Thank me in cash," was Boyd's closing remark.

So Draut wasn't hiring his Angels through his own personnel department. Where in blazes, then, were they coming from? Overseas, perhaps? If Draut was planning some sort of action against the government, there were lots of countries that would be only too willing to help. Or perhaps he was hiring from the ranks of illegal aliens. But then how was he finagling

the payroll records, which Personnel should have? Or maybe—

Or maybe there were no Angels at all.

Petrie stopped dead as that thought struck him. It sounded insane . . . but why not, really? No one outside the corporation had ever claimed to have touched an invisible Angel, or even to have watched one become invisible. With all communication handled through the neckbands, moreover, it would be easy to simply set up a bunch of men with radios and sensor screens pretending to be Angels—ordinary men, without any special combat training or licenses, who could be hidden almost anywhere among Personnel's files.

But why would Draut do something that crazy?

Petrie couldn't guess the answer to that one, but for the moment he didn't need to. All he needed to do was to make the accusation in his next article. If true, Draut would have a lot of explaining to do. If not, it should at least force the old man to cough up some useful information, something that might give Petrie a clue as to what he was *really* up to. All in all, a fair gamble.

Grinning tightly, Petrie headed for an exit. Charlie, his editor, was going to flip over this one.

"We'd better start for home," Mrs. Lieberman remarked with some regret. It was a lovely afternoon, sunny and warm, and she hated the thought of being cooped up in her apartment all evening.

Michael's sigh was just barely audible. "Mrs. Lieberman, I wish I could convince you that you really don't have to go home this early when I'm with you. I realize you have half a lifetime of habit to overcome, but you really *are* safe with me. I'd hoped that nearly two weeks together would have convinced you of that."

"I know, Michael, I know, and I don't mean to insult you or anything. It's just . . . well, sometimes it's hard to believe you're really *here*. You walk so quietly, never bump into anybody, never touch me on the arm. I guess deep down I'm scared you're just a figment of my imagination."

"I'm sorry," Michael said after a short pause. "I wish I could let you touch me, but I have orders against that."

"Orders?" She'd been assuming he was merely shy. "Why, for heaven's sake?"

"Well," he said, lowering his voice confidentially, "for all I know you could be a lovely and dangerous Russian spy in disguise, plotting to steal the secret of invisibility. If I let you touch me, you might suddenly spring into action, wrestling me to the ground and beating me into unconsciousness. Then you would spirit me back to Russia where you'd receive a medal and a plush Moscow apartment."

She couldn't help it. The picture that evoked was so absurd that she threw back her head and laughed until she was gasping for breath. "Michael, you're a gem," she said when she got her wind back. "All right, I give up. Let's go to a movie. There's one playing near here that I've been wanting to see for ages."

The sun was low in the sky and the last remnants of rush hour traffic were beginning to clear out when they emerged from the theater. "Where is everybody?" Mrs. Lieberman asked, more to hear herself speak than for information. She had never seen the streets and sidewalks so quiet and it suddenly made her very nervous.

"It's dinner time; most people are eating. Are you hungry?"

"A little, but I'd rather eat at home." Where she could feel safe.

"Okay. Let's go. We can catch a bus a couple of blocks from here."

She had gone almost a block when the muggers came up behind her, and they came so silently she never knew they were there until her arm was suddenly grabbed and her purse torn from her grasp. She turned, pulled off-balance by the hand on her arm, and saw her attackers: two weasel-faced teenaged boys. One was clutching her purse like a prize, but she saw him only with peripheral vision—her full attention was on the boy still holding her arm. His eyes smoldered with

hate, and even as she shrank from that glare he raised his free hand to strike her.

The blow never fell. Without warning, his head snapped backward and his grip on her arm was broken. He staggered back and doubled over as something jabbed him in the stomach. The second boy gasped, swore, and turned to run, but he got less than two steps before his legs shot out from under him and he made a painful-sounding landing on the pavement, the purse still in his hand.

It was an amazing sight, so much so that Mrs. Lieberman forgot she was frightened. "Why, Michael," she said. "You really *are* here."

"Of course. I—"

He broke off, and she turned just in time to see the first boy lurching forward, a wicked-looking knife gleaming in his hand. "Call him off, bitch," he gasped, his eyes on her neckband. "Call him off or I'll kill you." The knife slashed upward—

And froze in midair.

She watched in fascination as, against all his strength, the boy's hand was slowly forced down. With a clatter, the knife fell to the ground and flew, as if kicked, a few feet away. In the near distance a siren could be heard.

"I alerted the police," Michael explained. "I'm afraid we'll have to wait here until they arrive. Are you hurt?"

"No, I'm fine. And I don't mind waiting." Mrs. Lieberman retrieved her hat, which had fallen off during the attack. Dusting it off, she took a moment to glance at the sky. Some of the clouds were already turning pink; it was going to be a glorious sunset. "I'm not in any hurry," she added.

Hands jammed into pockets not really designed for such abuse, Petrie strode along in the late-morning sunshine, heading back from his latest defeat at the Draut Building and glowering at the world. He hated making a fool of himself—and four weeks after the fact, he still hadn't forgiven Draut's Angels for their rotten timing. Of all possible days for them to grab the head-

lines, they had *had* to pick the day he was submitting his story about them for Charlie's approval. No fewer than three separate attacks within a twenty-four-hour period had been stopped by the Angels, their elderly charges escaping unscathed. Naturally, this had had the side effect of turning Petrie's story into instant scrap paper, and an angry Charlie had hauled him onto the carpet the next morning for a canned lecture on proper research methods. He'd then shredded the story, of course.

Petrie had jumped the gun, obviously; he admitted as much, and had tried for a month now to rectify the error. But every approach still ended at either a dead end or a locked door. It was as if Guardian Angels, Inc., had brought Daedalus in as consultant on its corporate structure planning.

Which did nothing to ease Petrie's suspicions. Draut hadn't built this hermetically sealed labyrinth for the fun of it. The apparent proof that invisible Angels actually existed simply looped things back to the original question: what was Draut really up to?

He was picking at the issue for the twelve millionth time when he happened to glance down a cross street he was passing. Halfway down the block a well-dressed young man was talking earnestly with an elderly woman. In the man's hand was an object that looked suspiciously like a Guardian Angel neckband.

Without a pause, Petrie turned down the street toward them. Waiting until he was just within earshot he dropped his comb, and spent a few seconds retrieving it. The man and woman kept their voices low, but Petrie's hearing was good.

"But it doesn't really work, does it?" the woman asked in an asthmatic voice.

"Course not; not for five bucks. But who's to know? It's like a 'beware of the dog' sign without a dog."

Picking up his comb, Petrie continued on his way until he reached the corner. He looked back then and saw both people heading toward the street he had just come from. The man was the faster and had already

nearly reached the corner. Petrie hurried after him, afraid of losing him in the crowds. The old woman, he noted in passing, was wearing the neckband.

Petrie followed the man for nearly two hours as he traced a winding path through the city's streets. During that time he accosted nearly a score of old people, six of whom stopped to listen to him. Two of those bought neckbands.

Finally, just before one-thirty, the man's pace quickened and the aimlessness of his direction vanished. Walking a few blocks, he disappeared into one of the side doors of the Draut Building.

Petrie halted across the street, head spinning. It was, almost literally, the last place in the state he would have guessed the man was heading for. And he wasn't just a casual visitor, either; from experience Petrie knew those side doors admitted only authorized personnel. But why would Draut's people be peddling fake Angel neckbands on the streets? As a private black-market scheme it was petty in the extreme; as official corporation practice it made no sense whatsoever.

Unless. . . .

The faintest hint of an ugly thought began to touch Petrie's mind. It was almost ludicrous, but it fit all the facts . . . and if true, it was a blockbuster.

Except that at the moment he had nothing to back up his suspicions. And if he touched the wrong nerves digging that proof out, he could find himself inhabiting a deep hole in the ground.

The thought was both sobering and infuriating, and it made his decision for him. He wouldn't give the corporation time to react, but would confront Draut himself and try to force a confession from him. Prying himself from the wall where he'd been leaning, Petrie set off down the street, glancing once at his watch. There would be just enough time.

It was nearly five when he returned to the Draut Building, and this time he didn't allow secretaries or receptionists to stop him, much to their collective con-

sternation. He was barely one jump ahead of Security when he strode into Draut's outer office.

The secretary there was surprised but unflustered. "Yes?" she asked coolly.

"I want to see Draut," Petrie told her. "Tell him I know about Guardian Angels and the twin fraud he's running with it, and that I'd like to talk with him before I blow it up in his face."

Four burly security guards came charging in before the secretary could reply. One of them had grabbed Petrie in a no-nonsense aikido hold and was marching him toward the door when a voice came from the intercom. "Ms. Smith, please ask the young man to step into my office."

The guards froze in disbelief but, at a nod from Ms. Smith, reluctantly released him. Taking a deep breath, Petrie pushed open the heavy mahogany doors and entered Draut's private office.

The room was roughly the size of a miniature golf course, and was all leather, oriental tapestry, deep-pile rug, and dark wood. One entire wall was floor-to-ceiling windows with a spectacular view of the city below. In the center of the room, standing next to a huge desk, was Draut. "Good afternoon," he said as Petrie hesitated. "You wished to see me?"

Petrie stepped forward, determined not to be intimidated by the surroundings. "My name is Petrie, Mr. Draut. Before I begin I want to warn you that I've given sealed letters to five friends which outline the accusations I'm about to make. If I don't retrieve those letters by eight this evening their contents will be made public."

Draut smiled faintly. "Not very original, but certainly melodramatic."

Petrie ignored the comment. "I've wondered for several weeks about your motives and purposes in setting up Guardian Angels, and I've come to the conclusion that the whole thing is a fraud. Not only are there *no* invisible people for you to rent out, but you have the colossal gall to peddle fake neckbands to old people

who think there's really somebody around to protect them."

"Of course there're no invisible men," Draut shrugged. "The concept was proved impossible decades ago."

Petrie had expected a denial. Draut's casual admission threw him off his stride, and he fumbled a bit in getting out his next words. "You've got people somewhere in the city using phased force beams, right? Using the neckband sensors to aim the things?"

Draut nodded. "They operate from a handful of centers scattered throughout the area. With sophisticated military targeting equipment, of course, the beams can be most effective in simulating the actions of an 'invisible man.'" Something in Petrie's face must have mirrored his thoughts, because Draut's mouth twitched in another faint smile. "I'm not telling you all this because I have a trusting soul and you have honest eyes, Mr. Craig Arnold Petrie of Wynne, Arkansas," he said. "You've been buzzing around this building like a hornet for almost two months now and I've had you thoroughly checked out. You seem to me like a man who can probably be trusted with the whole story but not half of it."

"If you're trusting me to keep quiet about this chicanery, you're a lousy judge of character. I'm writing the story, and the minute it breaks you and Guardian Angels will be finished." All of Petrie's anger had evaporated in the past few moments, leaving only disgust in its place. He'd had visions of a diabolical plot against nations and had found, instead, a petty con game. He'd expected more from J. Thaddeus Draut.

"Finished?" Draut shook his head. "No. In fact, we've hardly started. Next week we're beginning new testing operations in Chicago, Pittsburgh, Detroit, and Cleveland."

"What are you talking about? You try leasing 'invisible' bodyguards now and the FTC will—"

"Who said anything about leasing anything to anybody? Those test centers will be just like the one here, giving free Angel service to some of the poor and elderly."

Petrie blinked. "What?"

"As I said, you need the whole story. The so-called 'testing phase' is all there is to Guardian Angels, Inc. The rest of the noise we've been making about it was just for publicity purposes, to make sure everyone knew about it."

An uncomfortable suspicion was beginning to creep up on Petrie. "Wait a minute. Are you trying to tell me you're running some sort of charity protection racket? What on Earth for?"

Draut looked him in the eye for a long moment, then dropped his gaze. "I could tell you about my childhood in Cleveland, I suppose. Or about the time my mother and sister had their purses stolen—but I'll just say I'm doing it because it needs to be done. For decades the poor and elderly have been at the mercy of both criminals and those who simply want to take out their frustrations on someone else. No one's done anything about the problem because the government can't afford it and there's no profit in it for anyone else. So okay. I've got money I don't need, and I'm taking a crack at it. Maybe it won't work, but maybe it will. I think it's worth a try, anyway."

Petrie thought about that for a moment. "Why the fiction about invisible men? Why not the truth?"

"Partly publicity, as I said earlier. We needed to make sure potential muggers were aware of us and could associate the neckbands with our Angels. That's the main reason we made the neckbands so big and obvious."

"A deterrent."

"Of course. And secondly, there's a strong psychological kick this way. You tell your average punk that someone two miles away is fiddling knobs on a pair of phased force beam generators and he might take his chances. But tell him there's an invisible man waiting to clobber him?" Draut shook his head.

"Yeah. And the fake neckbands—additional deterrent?"

"Sure. You can't tell them from the working ones, and nobody knows where those are—we made sure of that. And we'll be adding real ones every so often and shifting others around, just to keep things uncertain."

Petrie nodded. Taking a deep breath, he expelled it in an inaudible sigh. "It won't last, you know, even if you convince me to sit on the story. One of your own people will leak it, or another reporter will figure it out eventually."

"I know that. But the longer we maintain the facade and the more attacks are beaten off, the more confidence people will have in us. I'm hoping that when the lid comes off it won't matter much because we'll have proved we can do the job. My people won't talk; they're all carefully screened, highly idealistic young people who believe in what they're doing. So I guess it's up to you and your colleagues."

"I'll have to think about it."

"Do so," Draut urged. "And while you're deciding I suggest you take a walk through Central Park. Count the number of people there—*real* people, not just muggers. Observe how already they cluster near someone wearing an Angel neckband, and remember that even two months ago none of those people would have dared to go near the place. Good evening, Mr. Petrie."

The trip through the halls and down the elevators took several minutes, and once outside the range of Draut's personality Petrie again began to have doubts. Good motives or not, Draut *was* lying to the public. Didn't they have a right to know that?

He left the building, and as he did so an old woman in a strange-looking hat and an Angel neckband caught his eye. She was walking toward him, her lips moving as if talking to someone, though he couldn't hear her words through the din of traffic. She was nearly abreast of him when she noticed him watching her. Smiling pleasantly at him as she passed, she continued her conversation, and he caught a few of the words: "... and I promised Mrs. Finch we'd take her along to the park, Michael—don't let me forget . . ."

Petrie made his decision. The hell with Draut's suggested stroll through Central Park; he had work to do. There were five envelopes he had to pick up before eight o'clock. Turning, he hurried down the street.

TIMESWARPS REVISITED

It is a well-known scientific fact that physicists tend to break down in the presence of black holes. Given what Dr. Gribbin supposes might happen when you rotate the singularity, at least some physicists must rotate as well. Certainly the process described herein would set Einstein to spinning in his grave: thus we would have not just time travel, but action at a distance.

—JPB

TIMEWARPS REVISITED

John Gribbin

Is time travel possible? A few years ago, I wrote a book called *Timewarps* in which I answered that question with a qualified "yes." Time travel is possible, I concluded, but it all depends on what you mean by time travel. Now, I'm not so sure that the qualification is needed. The reason for my change of heart, or mind, is the work of a remarkable American mathematician, Frank Tipler. Associate professor of mathematical physics at Tulane University, New Orleans, Tipler seemingly delights in turning conventional ideas on their head, using detailed statistical and mathematical arguments to claim, among other things, that time travel really might be possible in our universe. So here is a summary of Tipler's description of how to build a time machine, a description drawn in part from a very mathematical paper published as long ago as 1974 in the highly respectable journal, *Physical Review* (D, vol. 9, p. 2203), and in part from discussions and correspondence I had with Tipler.

By a nice touch of irony, Tipler's thoughts on the possibility of time travel are probably known to a wider readership than most esoteric scientific ideas, but that readership may not appreciate that these ideas are "real

science." The reason is that the ideas first emerged into the world beyond the readership of the *Physical Review* in one of the shortest stories by SF writer Larry Niven, a piece with the catchy title "Rotating Cylinders and the Possibility of Global Causality Violation," a title which Niven acknowledges he stole from Tipler's 1974 paper. The story depends on the assumption that the work described by Tipler in that paper can be taken at face value, implying that it is possible to construct a working time machine based upon the rotation of a very long, massive, and suitably rigid cylinder constructed in space.*

That's all very well, but usually such exotic ideas are aired in the scientific literature hedged about with caveats to the effect that "this is not expected to apply in the real universe," or some such qualification. So when I contacted Tipler to find out whether he really believed that time travel was possible, I was both surprised and pleased by the positive tone of his response that "my current view is that there is indeed a real theoretical possibility for causality violation in the context of classical general relativity," and his only caveat was the remark, "that is, I feel the question is still open." "Causality violation" is what you or I mean by "time travel." The point is that if time travel in the fullest sense is possible, then effects can be seen to precede their causes, instead of following. Causality is violated, for example, if you walk into a room and the light comes on, and then you turn on the switch that allows the current to flow; or if the winner of the 3:15 at Newmarket is announced and then I pop back to 2:30 to place my bet on the winner.

There is a widespread and general assumption among mathematicians and physicists (and others!) that causality cannot be violated, but this is no more than an assumption, based on the common sense view ingrained by everyday experience. So deeply is this view in-

*Niven's story can be found in the collection *Convergent Series*, Del Rey/Ballantine, New York, 1979.

grained in us that any theory which allows, or predicts, causality violation is usually regarded on those grounds alone as a "bad" description of reality. But this is only a prejudice; Tipler and a few others argue that we should at least keep open minds at present. General Relativity has stood every other test over the past half century; now it is seen to predict causality violation, and there is as yet no proof that it is wrong on this count, either.

So to attempt to answer the question of whether time travel is possible, Tipler has used the best mathematical description of spacetime that we have, and he has broken the problem down into three main parts:

First, do the equations allow in theory for the existence of journeys through spacetime in which the traveler returns to his starting point in both space and time, having traveled "backwards in time" for part of the journey?

Secondly, if so, is it possible for the conditions under which such journeys are possible to arise naturally in the universe?

And, thirdly, is it possible, in principle at least, to create such conditions artificially; that is, to build a working time machine?

It turns out that the answer to all three questions, within the framework of General Relativity, is "yes." But first, let's take a quick look at that theoretical framework.

What we learn from special relativity is that time intervals experienced by people and measured by physical clocks depend on the particular path they follow through spacetime. If two spacetime paths coincide initially and intersect later, and one path is accelerated while the other is not, then the time length of the accelerated path will be shorter—less time will have passed for the traveler following this path. But he can never exceed the speed of light (at which time would stand still for our hypothetical observer), and can never travel backwards in time. Our passage through the four-dimensional fabric of spacetime is confined within a region bounded by paths corresponding to light rays

radiating from the here and now, a region called the "future light cone." And our knowledge of past events in the universe is confined to information coming in from a similar four-dimensional cone extending into the past, the "past light cone." In practice, relativists compress the three dimensions of space into one representational dimension, allowing them to plot two-dimensional diagrams on paper, with the flow of time represented as "up the page" and movement in space as "across the page." On such a spacetime diagram, one quarter of the page represents the future light cone, one quarter the past, and fully half of spacetime is inaccessible and unknowable, and called "elsewhere."

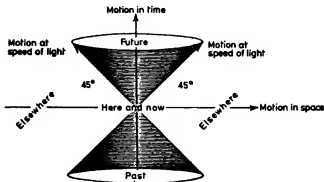


Figure 1: The "future light cone." By choosing the speed of light to be one unit, by definition, the path of a light ray in a standard spacetime diagram is a straight line at 45 degrees to the time axis. Because nothing can travel faster than light, starting out from here and now we can never move outside the future light cone, or receive information about anything outside the past light cone. More than half of spacetime is inaccessible, according to relativity theory, and is called "elsewhere."

But special relativity takes no account of the effects of

gravity, and one such effect, spelled out by General Relativity, is that the presence of matter in a region of spacetime causes nearby light cones to "tip over" in the direction of the matter (light rays are "bent" by gravity). If the matter is rotating, it further distorts spacetime in its vicinity, creating a dragging effect which tips the light cones over in the direction of rotation. And if the mass involved is big enough, and the rotation is fast enough, then the light cones tip over so far that the coordinate used to measure space and the coordinate used to measure time become interchanged. In practical terms, the roles of space and time have been reversed, and by the entirely legitimate process of changing

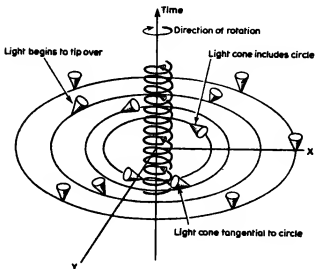


Figure 2: Near a massive rotating object, spacetime is distorted, so that the light cones in local regions tip over. A traveler, or message, can only move forward in time within a light cone, but if the light cone points backward, then time travel is possible. (Based on figure supplied by Frank Tipler.)

his local space coordinate—moving through space—a traveler would move through time, as viewed from the region of spacetime outside the influence of the rotating mass. In Tipler's words, "a traveler could begin his journey in weak field regions—perhaps near the Earth—go to the tipped-over light-cone region and there move in the direction of negative time, and then return to the weak field region, without ever leaving the region defined by his future light cone. If he traveled sufficiently far in the minus- t direction while in the strong field, he could return to Earth before he left—he can go as far as he wishes into the Earth's past. This is a case of true time travel." In other words, the first part of the puzzle has been solved—general relativity does imply the theoretical possibility of causality violation. But is it practicable?

There is no guarantee that because a region of space-time like the one described by Tipler as "the strong field region" *can* exist then such a region *will* exist. Crucially, how much mass must there be in the rotating object, and how fast must it be rotating, for causality violation to occur? A slightly more subtle point is that because the light cones are not tipped over until the massive rotating object comes into being, there is no way to travel back farther in time than the instant of creation of the "time machine," whether it is natural or manmade. If we built such a time machine tomorrow, we could not use it to travel back in time and study the ancient Greeks; but if we found a natural time machine left over from the creation of the universe, then we could.

The realization that rotation can scramble up the orderly picture of space and time is nothing new. Einstein himself tackled aspects of the problem, and Kurt Gödel, an Austrian mathematician born in 1906 who died only in 1978, developed a mathematical description, a model, of a rotating universe which came to some similar conclusions. Gödel's model was developed thirty years ago, and contains features that most theorists find disturbing. In particular, it allows journeys in

which the traveler, by following a circuitous route through spacetime, returns to his starting point in both space and time—Tipler's eminently reasonable criterion of time travel. Such routes through spacetime are called "closed time-like lines," and the general reaction to Gödel's model is that the presence of closed time-like lines rule it out as a valid description of the universe, because "of course" causality violation is impossible. A closed time-like line (CTL) is simply a path through spacetime that returns to its starting point, making a closed loop and therefore looping backwards in time for part of its path. If a rotating universe contains CTLs, then in the eyes of most cosmologists that "proves" the universe is not rotating.

The question is rather academic, however, because even if the universe contains CTLs we would still have to find the right path through spacetime, and it is hardly likely that such a path passes within range of our rather limited spacefaring capacity. It might even involve traveling around the entire universe to get back to the starting point, even if we could find it. To find a natural time machine, it is more sensible to focus our attention on more local regions of spacetime, and lesser quantities of matter than the universe itself. Here, the mathematics gets too hairy for me, and like you I have to accept Tipler's credentials, and those of the journals in which his work has appeared, interpreting for you only the conclusions of his work, not the arguments themselves.* There is no doubt that General Relativity permits the existence of CTLs, but the standard way to test the physical reality of mathematical solutions to Einstein's equations is to change the parameters being

**The Physical Review is not the only learned journal to have published the relevant work; other papers have appeared in Annals of Physics, vol. 108, p. 1; Physical Review Letters, vol. 37, p. 879; and in the book General Relativity and Gravitation: One Hundred Years After the Birth of Albert Einstein, vol. 2, p. 97, edited by A. Med and published by Plenum in 1980.*

fed into the equations ("perturb the initial conditions") and see if the same solutions still come out. But it is hard to test whether CTLs are "stable" in this sense, because when dealing with a loop in time it is rather difficult to decide what you mean by the "initial" conditions. In terms of the practicality of time travel in our universe, Tipler's results lead, even so, to one important and seemingly unambiguous conclusion: A time machine cannot be created from ordinary material under ordinary conditions; CTLs can arise only if at least some matter passes through such extreme conditions that a singularity is created.

A singularity is a region where the matter density becomes infinite, and there is no way in which matter with arbitrarily large density can be considered "ordinary." On the other hand, most relativists accept that singularities do occur in the ultimate collapse of matter within black holes. Such a singularity cannot be seen, because it is surrounded by an event horizon, and the snag for prospective time travelers is that while they might be able to cross the horizon on the way to the "time machine," they could never get back out into our local weak field region of spacetime. You cannot, in other words, have a practical time machine without a *naked* singularity, one that is not surrounded by a black hole event horizon.

All is not lost, however, since as Stephen Hawking has shown, black holes aren't black, and tend to evaporate over a long period of time, eventually exploding outwards and exposing the singularity inside to outside view. If the singularity also had angular momentum—if it were rotating—it would be a working time machine with CTLs. Such a time machine could arise naturally, from a small black hole left over from the Big Bang—and although in that case the high field region of distorted spacetime would be too small for even an electron to actually take advantage of time-traveling opportunities thus presented, that means that the second part of the time travel puzzle can also be answered in the affirmative. All that remains is to find a way to create

such a time machine artificially. It might be done, in principle, by capturing a mini black hole and cooling space around it to speed up its evaporation until a naked singularity appeared. We might even imagine means of manufacturing such a black hole in the first place, using powerful nuclear fusion devices. But the best prospect is the one picked up by Larry Niven—take a compact rotating body and speed up its rotation far enough, while somehow ensuring that it doesn't collapse along its axis (which, says Tipler sadly, would be very difficult to arrange for a rotating cylinder with any finite length). When the rotation is fast enough, a naked singularity will form at the center of the rotating cylinder, and CTLs will come into existence.

The naked singularity need not remain in existence for any appreciable time, however, since once the CTLs are formed they are forever tied to the singularity, no matter how brief its existence, by their curved paths through spacetime. That does a great deal to make up for the obvious difficulties in construction of such a machine, since it only has to exist for a fleeting instant to open up all of the future of the universe to exploration.

So Tipler concludes that not only are CTLs not ruled out by any fundamental physical principle, the construction of a working time machine is a theoretical possibility. The problems that remain, although impressively large, are essentially engineering problems. It would be possible, with the use of some sophisticated and expensive engineering, to set up a time machine.

How sophisticated and expensive would the engineering have to be? Some idea of the difficulties still to be overcome can be gleaned from some very "iffy" numbers Tipler quotes. If the approximations in his calculations which apply, strictly speaking, to infinitely long rotating cylinders still hold for finite cylinders, then the ratio of length of the cylinder to its radius would be about 10 to 1. If this finite cylinder has the same field effect in the CTL region as an infinite cylinder; and if stabilizing could be done without the need for extra mass (Tipler stresses that, in his view, this may

be impossible even with extra mass); then a cylinder with a mass density of about 10^{14} grams per cubic centimeter (the density of the nucleus of an atom, or of a neutron star), a radius of 10 km and a length of about 100 km, having a total mass roughly equal to that of the sun, and rotating twice every millisecond so that the rim of the cylinder is moving at half the speed of light, would be a working time machine. In other words, a time machine would be like an elongated, rapidly rotating neutron star. Apart from the stability problem, the specification is remarkably like that of a young, recently formed pulsar. And although no known pulsar rotates quite that fast, there is one, called the "millisecond pulsar," which spins once every $12\frac{1}{2}$ milliseconds. That is getting very close to Tipler's specification—although none of the popular accounts of this strange object seem to have mentioned that it almost fits the description of a working time machine. Given all the uncertainties involved in the calculations, it would be *very* interesting to see what happened to a robot probe sent to orbit this beast.

It is a very surprising and dramatic discovery that a working time machine should bear such a close resemblance to objects that occur naturally in the universe, and the suggestion doesn't seem to have caused anything like the stir in astronomical circles—and outside—that it should. Bearing in mind the advances in engineering we have made on Earth in the past millenium, the prospect of tweaking up a naturally existing pulsar to create, for the brief instant that is required, a working time machine looks entirely feasible for a civilization not much more advanced than our own. But before you get too excited, Tipler has a parting shot to impart. Would such a working time machine actually be of any practical use?

"I would imagine," says Tipler, "that if such a device were created, it would be used only to send messages, not physical objects, back into time. It would take enormous energies to send a physical body back—energy at least as great as the rest mass of the body. You can

see this by imagining a body of mass M sent back in time and returned close to the event at which it started; far away from the time machine, there would be two bodies with mass M , and the extra rest-mass energy has to come from somewhere. In effect, the machine acts as a matter duplicator."

Another operating difficulty would be posed by the enormous tidal forces associated with the strong gravitational field of a small time machine; but Tipler stresses that there is no theoretical barrier to the movement of particles of matter through the time machine, and for small masses, even the energy cost of the matter duplication process would be less than the energy costs involved in building the time machine in the first place. A civilization rich enough, in energy terms, to build the machine would probably not be daunted by the cost of running it. And even the prospect of sending messages through time is enough to pull the rug from under the "causality is common sense" school of thought. The physicists may not like it, but it is certainly good news for SF writers and readers. Come on, Larry—how about taking up the challenge?

John Gribbin's latest books include Spacewarps (Delta paperback) and In Search of The Big Bang (Bantam). He threatens to use the ideas in this article in his own SF story if someone with real talent in that direction doesn't do so first.

THE ARMISTICE

Tim Zahn examined the brighter side of a technology with a pretty dark rep. Robert Reed takes the opposite tack. Our perception of computers and artificial intelligence is currently conditioned by some pretty nifty machines and just a whole lot of hysterically positive advertising; these machines aren't just powerful tools, they're so user-friendly they're downright convivial!

Of course they don't have to be friendly. A genuinely smart weapon with all the latest stealth and beam-weapon technology could be one mean machine. And if it is to effectively distinguish between its owners and spoofing enemies, then our hypothesized weapon's friend/foe recognition routines must be powerful and flexible—and thus subject to bugs and degradation. Perhaps one day the wrong circuit might snap permanently closed. . . .

—JPB

THE ARMISTICE

Robert Reed

"Hey! Hi! Hello!"

The soldier, named Forbes, was climbing a steep gully near the world's end, his bare bald head down and his right foot easing over the trunk of a dead ash. Then he heard the voice, happy and quick and strange, and he froze for an instant, waiting, watching half a dozen empty water sacks and one oiled and ready machine pistol dangling from his shoulders and his bulldog neck.

"Glad to find you!" said the voice. "Come on up! Let's talk!"

He let his foot down, reached and gripped the big pistol's handle, then snapped off the safety and lifted his head until he could see a tall figure. The figure waved him on, neighbor to neighbor. Forbes let out a breath, let go of the pistol, and continued. He crossed the tree and used both hands to balance and to pull himself up the stony slash.

Water, green and warm, trickled at his feet. He had come all this way, to the world's end, hunting water.

"And your name, sir?"

"Forbes."

"Can I help you, Lt. Forbes?"

"By steering clear."

He had this one understood, in part. He didn't even bother watching it, he felt so sure. Sometimes they used torture, and some of them were just plain boring—a peculiar way to be, considering what they were. But this one had a spark he hadn't seen in months. So what he did was nothing. Scrambling to where he could stand even with the thing, he just paused and quietly regarded it, allowing it to have the next move.

It seemed completely human. It looked like any bearded, middle-aged man. Dressed in shorts and a shirt with endless pockets, it carried rock hammers and a compass on a leather belt. The boots looked better than Forbes' own, and the socks were mismatched.

"Your name's what?"

"The Professor." It was smiling. Beaming. "I'm glad to see you've come. We've got a fair amount of material to cover."

Just like a professor, he thought. Right down to the socks. "All right, Professor. Start professing."

"Pay attention," it said. "There'll be a test."

Here the gully was wide and only slightly sloped. The bare stone was punctuated with mounds, each mound maybe half as wide as it was tall and never taller than Forbes' knees.

The Professor sat itself down on one of the mounds; Forbes did likewise, laying the pistol on his lap.

"Do you, by any chance, know a stromatolite when you see one?"

Forbes shook his head. "Nope."

"How about photosynthesis? Do you understand the concept?"

"Food from light," he said, speaking with an even voice. "Used to be from sunlight—when we had our sun."

"Indeed." From the belt it took a hammer. With a brown-spotted hand, it drove the pointed end into a mound between them. There was a crack, a rain of shrapnel, and The Professor used the hammer to point at the freshly exposed surface.

"Can you see the lines, Lt. Forbes? Can you tell how the mound is made of layers?"

Like the rings of a tree, sure."

"Exactly." The Professor put the hammer on the belt again. "Except that the layers are stacked one on top of the other. Which is a quality shared by all stromatolites."

Forbes said nothing, watching everything.

"There was an age, back near the beginnings of Earth, when stromatolites dominated the landscape. We know, through physical and chemical fossils, something of their history. . . ."

"Great."

"They formed in shallow seas. Simple microbes, growing in mats, were sandwiched between layers of grit and muck. The stromatolite shape came about because of currents and happenstance growth. The mats laid over them and ran for miles, trillions times trillions of tiny cells all connected."

Forbes pushed his tongue against a cheek.

"I've studied them and learned two things." It patted the shattered mound affectionately. "First, the mats were intelligent. In a slow way, granted, but possessing real thoughts, a sense of identity. Just like me, and like you, able to recall and plan, only in a creeping way, century by century."

"You don't say?"

The Professor nodded. "And secondly, individual mats fought for space and resources. Just as life anywhere does. Where they touched they fought in their own peculiar ways, their wars lasting millions of years. And just like wars anywhere, the stakes were terrible and the consequences worse."

"Huh."

The Professor said, "Some microbe mat, billions of years ago, found the perfect weapon. Using sunlight, it split water and made pure oxygen." It blinked. "Oxygen then was toxic. Very toxic! Life hadn't yet adapted to it, and so, when channeled toward some enemy, the genius mat had a clear advantage."

"Till other mats learned."

"Exactly, sir! You have it!"

Forbes said nothing, thinking to himself.

"Thus, you see, the mats began to change the atmosphere. Oxygen from that day on grew in abundance until—"

"You're boring."

"Pardon?" It blinked in a large way.

"You bore me. Pick up the pace." He drew quick circles with the pistol. "I'm tired and thirsty. Give me the punch line, and now."

"You don't see?" the thing wondered. "The parallels are obvious."

"Which parallels?"

"The microbe mats waged wars and changed their world. They made it so that new, more complex organisms could arrive and thrive and push them off into near-extinction."

"What? You've come to gloat?"

"No, not at all." Suddenly it seemed sad, full of a peculiar gloom. "I've come to tell you something about this place. Here." It struck the ground with a bare hand, and Forbes felt the blow resonate up through his butt. "Will you listen, please?"

"Go on."

"You will?"

"Talk."

It said: "The last great stromatolite plains, preyed upon by the new fishes and the stupid trilobites, came to an agreement. They would no longer fight against each other. They saw, finally the true enemy, and they vowed to join together and fight the oxygen-breathers, even though they had no hope. Not a prayer."

"So?"

"They called an armistice. Here." It knelt and said, "Two mats lying side by side here made a truce. True! I can read the fossils plainly. That's what the chemical traces say!"

"You *are* gloating, aren't you?"

"No," said The Professor. "No, I'm apologizing—"

"I hate gloaters." Forbes shot. The bullets, dressed

in teflon suits and explosive underwear, took the body apart. Glass wiring and frigid liquids spilled all over. An arm quivered, jerked, then quit. Then, without a worry in the world, Forbes removed the boots and tied the laces together, swinging them over his shoulder and continuing on his way.

Higher up the gully was a pool of water, green and buggy enough to mean it was safe to drink; he filled the sacks, tied them closed, and went slowly down, stopping at the corpse again.

He built a fire. With the dead ash and other scrap, he covered the corpse before he struck a match. It was duty to habit. During the bad times they'd always done this. There was no other way to make sure their brains—so tiny and so fast—were truly destroyed. Funny as it seemed, they just couldn't take the heat.

For a few minutes he stood, listening to metal pop and thinking about all that the machine had said.

Forbes examined the ancient stromatolites one last time, then turned and left.

His bike waited on the road—fat tires and a heavy frame and one good gear to its name.

He tied on the water sacks and boots, then swung his pistol over his back and rode. The way was dirt, soft and slippery dry. The bluffs rose on his right, the dead river lay to the left, and for better than an hour he managed to pedal without resting once.

The road bumped across the dead river, rose, and reached the crest of a low hill.

Forbes dismounted, drank and ate a little something from his pannier, breathing hard, leaking sweat into the thirsty dust.

He was near the world's middle now. All around, save on the north, he could see what rose beyond—high dark towers, angled and crazily interwoven, where the machines ruled completely.

Since Forbes had been a young man, it had all looked this way.

To the south, stretching from Earth's belt to Clarke's orbit, were towers intermeshed like some insane black

lace. What passed for a sun these days came from there—a tiny and almost bright light thrown down at the world, lending to everything a pale white color and sharp dark shadows pointing north.

The sun vanished twenty years ago; the machines had discovered a way to turn it off and so save it, sipping the precious fusion fuel instead of letting it burn at will.

All the planets were like Earth, only more so. Dismantled, Forbes understood. Gone so fast that his head spun, considering it.

He thought about the microbe mats again. Briefly.

Then he stood and rode again, heading due north.

Why the world? He wondered sometimes. Why haven't the machines come closer in all these last years?

There was the notion, among some, that people here lived on hallowed ground. At the world's center was an old command post, used in the times when the war was purely man against man.

Do machine loyalties remain, even after so long?

Are there other worlds on Earth—gaps where air and water and light are trickled in, allowing a meager existence?

And what about the machines that come here, dressed like people and trying to tell us things? Forbes, and most others, considered them to be throwbacks, rare and functionless in their own world. Like some horse with three hooves on a leg, they were crippled by ancient traits—traits valued tens of thousands of generations ago.

They seemed to feel an honest obligation to explain their work and thoughts. They were like machines of old, coming in from the battlefield to report to their masters.

There never was retribution for destroying them.

Even the machines themselves seemed ready to die in their old masters' hands.

The Professor, all things considered, had seemed to be one of the more lucid oddities in quite a long while.

Forbes thought about that and a hundred other notions, pedaling along.

He'd never actually fought the machines. No one had tried to in any serious way. There are times, he knew, when things are so tilted in one side's favor that debating the point is silly. It's best just to stay out of the way.

It was the machines that fought each other—just like they were built to do. And when their powers expanded, and their numbers and cleverness, they began to split into new nations of their own. New alliances. They took their own evolution into their own control and struck outwards. If people were in the way . . . well, they'd mostly lost their old imperatives, their old set of ethics and manners.

Coming over another hill, Forbes could see campfires flickering in the dusty distance.

"Apologize," he wondered aloud. "For what?"

Sometimes there'd be wars, and Forbes and his pals would watch. The towers down at the equator, reaching up twenty thousand miles or more, would flicker and crack and sometimes shake enough for the motion to be seen.

But wars ended fast. The machines lived that fast. New alliances would form, or the old would end, and there'd be peace for a time. The damage would be patched, mostly in a day or two, and for several weeks the quiet would hold.

Those things had some incredible weapons, he thought.

He'd seen in his life fights that were so strange they were pretty—the stars flickering on and off, gravity changing underfoot, the rules of the universe bent all out of shape. . . .

"Apologize, it said. Not gloat."

Braking, he stopped and got off the bike and looked back. Up and back. Those enormous towers showed no sign of motion, no trace of change. Now that he realized it, there'd been quite a stretch since the last time a war, small or not, had broken out. Weeks at least. Maybe months.

Climbing back on, he hurried.

Suddenly he felt an urge to make it home, and he began laughing weakly as he cut through the dry wind.

Some things never change, he was thinking. That's its message. Yeah, sure. That's the point.

Behind him the false sun went out.

"A little early for night," he said, laughing softly.

Camp was ahead. Almost close now.

"The dumb sons of bitches," he was saying, talking about everything that had ever been.

LEADING EDGE

Roland J. Green

Arthur C. Clarke, *The Songs of Distant Earth*. New York: Del Rey/Ballantine Books, 1986. \$17.95.

Gregory Benford and David Brin, *Heart of the Comet*. New York: Bantam Spectra, 1986. \$17.95.

Clifford Simak, *Highway of Eternity*. New York: Del Rey/Ballantine Books, 1986. \$14.95.

Theodore Sturgeon, *Godbody*. New York: Donald I. Fine, 1986. \$14.95.

Joan Slonczewski, *A Door Into Ocean*. New York: Arbor House, 1986. \$17.95.

Andrew Greeley, *God Game*. New York: Warner Books, 1986. \$16.95.

Tim Powers, *Dinner at Deviant's Palace*. New York: Ace Books, 1985. \$2.95 paperback.

Robert Holdstock, *Mythago Wood*. New York: Arbor House, 1985/Ace Books, 1986. \$14.95/\$3.50 paperback.

Barry Hughart, *Bridge of Birds*. New York: Del Rey/Ballantine Books, 1984. \$2.95 paperback.

Melissa Scott, *A Choice of Destinies*. New York: Baen Books, 1986. \$2.95 paperback.

Lois McMaster Bujold, *Shards of Honor*. New York: Baen Books, 1986. \$2.95 paperback.

Melinda Snodgrass, *Circuit*. New York: Berkley Books, 1986. \$2.95 paperback.

The Report of the National Commission on Space, *Pioneering the Space Frontier*. New York: Bantam Books, 1986. \$7.95 trade paperback.

We start with a salvo of six big books, their caliber varies, but none of them is a big bore. . . .

Arthur C. Clarke's *The Songs of Distant Earth* is expanded from a novella of the same title. It is really two stories in one. One story is how the Earth of the next millennium faced the impending doom of a solar nova with rationality, discipline, composure, and common sense. This story is told largely in flashbacks.

The other story is what happened when the last starship to leave Earth, the *Maqellan*, had to stop for repairs at the water-covered colony world of Thalassa. Thalassa was settled some centuries before, by an automatic "seedship" carrying human genetic material and robots to tend the infants until they reached maturity. Into this stable little society comes the *Maqellan's* landing party, and the resulting collision of cultures jars both sides quite badly. Among its fruits is a child, fathered on a Thalassan woman by one of the starship's crew and doomed to be dead centuries before his father reaches his goal.

Clarke clearly believes in the human future in space. As nobly if less plausibly, he also believes in the evolution of human rationality and ethics toward a steadily higher level. *Maqellan*, for example, is not allowed to settle any planet with an existing ecology. Instead, her people will terraform a sterile world from scratch.

Not Clarke at his best, but an honorable addition to one of the outstanding bodies of work in the history of sf.

In *Heart of the Comet*, Gregory Benford and David Brin take a shorter-range view of our future in space and a more pessimistic view of our future ethics. When Halley's Comet returns in the 21st century, an expedi-

tion is sent to colonize and explore it. By the use of hibernation techniques, the expedition is expected to survive through the comet's next period and return to Earth with it in the 22nd century.

Unfortunately, the comet is teeming with life, from an ecology older than the solar system's. Much of it is hostile to Earth life. The expedition has to fight everything from exotic bacteria to carnivorous plants.

As if they didn't have enough trouble, the explorers also start fighting among themselves. The principal (but not only) line of division is between the Percells (genetically-tailored humans, named for their creator Simon Percell) and the untailored Norms. Civil war is quickly added to the assaults of an alien ecology.

The expedition is saved by the combined efforts of biologist Saul Lintz, Percell computer scientist Virginia Herbert, and hardheaded professional spaceman Carl Osborn. They are among the best-drawn characters in recent sf, and everything else in the book is at the same high level, including the scientific speculation and the pacing.

A masterpiece of hard-science sf, probably the best novel so far of 1986 (as of June 19), and the first fruits of a potent new collaboration.

Clifford Simak's gentle *Highway of Eternity* is his latest speculation on human evolution, a favorite topic since the days of *City*. A million years in the future, aliens have persuaded the human race to become disembodied intelligences. A few protestors have to flee in time machines, pursued across both time and space by the killer robots of the aliens.

One of those travelers turns up in contemporary New York, arousing the curiosity of a private detective. The detective asks a friend with the ability to "step around a corner" (teleport) to investigate what turns out to be one of the time machines. The two men are promptly caught up in the quest of the time travelers for safety from their pursuers. In time, this becomes a quest for

justice against the aliens who seduced the human race into a bogus immortality.

Simak's usual fine spare prose, lovely pastoral scenes, and well-done robots are all here in abundance. So is his lack of interest in the vicious side of human nature. Even the time traveler who ends up founding a cult with the aid of one of the killer robots emerges as more desperate than evil. This habit may keep the book in the emotional shallows for some readers. Others will honor Simak for not becoming another trendy purveyor or grunge for grunge's sake.

Posthumous novels are a notoriously uncertain proposition. One always likes to have more from a favorite author, but one wonders why the book didn't come out when he was alive? One also wonders if it has come out in a condition that he would really consider represents his intentions for the book.

Theodore Sturgeon's *Godbody* passes, if not quite with flying colors. It is a short and simple story of how God became incarnate one day in a small, puritanical Midwestern town, set everybody by the ears, and ended up being once again put to death.

The story is firmly rooted in Sturgeon's abiding conviction that love (defined here as the abandonment of Victorian sexual taboos) was the salvation of humanity. Those of us who feel that the limitations of this philosophy have been pretty thoroughly demonstrated in the last twenty years may have problems with the book.

They won't be insolvable problems, though, because Sturgeon has also managed a technical *tour de force*. He has told the story through eight successive viewpoint characters, bringing each character beautifully to life as he advances the story. Proof, if any was needed, that in Sturgeon we have indeed lost a master.

Joan Slonczewski's *A Door Into Ocean* has received much deserved praise for its world-building. The planet Shora is totally covered by water. For millennia it has been the home of a colony of parthenogenetic human

females. They have developed many ways of dealing with the physical and social problems they face, including a highly advanced, completely biological science.

The one thing the Shorans (or "Sharers" as they call themselves) lack is any capacity for violence, or even the concept of it. This inevitably causes problems when the neighboring planet of Valedon tries to rule Shora. Technologically conventional and male-dominated, Valedon's society is as incomprehensible to the Sharers as theirs is to the Valedonians. In this war, the first problem is to get the defenders to realize that they're being attacked!

After creating this fascinating world and a potentially exciting conflict, Slonczewski stumbles. Many of the events of the war and most of the Valedonian characters seem derived from feminist and ecology-movement concepts. This gives the second half of the book a predictability that drains away much of the emotional impact. (Once we've seen General Realgar getting nervous over his fiancée's adoption of the Sharer custom of nudity, we *know* he's going to turn out a Bad Guy.)

If Slonczewski ever writes a whole book as good as the first half of this one, it will be a real winner.

Andrew Greeley tends to try making sermons and stories pull in double harness, with varying degrees of success. In his *God Game*, he is more successful than not.

The priest-narrator (a somewhat autobiographical figure) is testing a friend's experimental interactive fiction game when lightning strikes his satellite antenna. Suddenly the computer links him to a world where the characters and situations of the game are real. Since that world still responds to commands from the computer, the narrator at the keyboard is now essentially that world's God.

Greeley piles on the philosophizing, about everything from the ethics of being God to his familiar antipathy to ecclesiastical hierarchies. He has also managed to tell a story, and create at least three characters who will stick

in most readers' minds. Duke Lenrau and Duchess B'Mella start out as hostile rulers and end as star-crossed lovers, while the "illel" (nature spirit) Ranora is an appealing combination of Irish witch and bratty teenager.

These three prize-winners are none of them new, but they deserve attention nonetheless for their sheer quality. Awards may come and awards may go, to greater or lesser controversy. As often as not, however, they are handed to books of genuine merit.

Robert Holdstock's *Mythago Wood* and Barry Hughart's *Bridge of Birds* shared last year's World Fantasy Award. The Holdstock begins from what is by now almost a conventional assumption in fantasy, that mythic beings arise from the Jungian collective unconscious. He then goes on to explain *how* they arise and interact with humans, and peoples a whole magical forest with them. When the narrator falls in love with one of the "mythagos," already claimed by his brother, it sets off as grim a story of pursuit and vengeance as any Celtic bard ever delivered. He's also left room for a sequel, which in this case would be no bad thing.

Barry Hughart's novel is aptly described as being about "an Ancient China that Never Was." The drunken Master Li Kao and the peasant boy Number Ten Ox journey clear across children of Ox's village of a mysterious plague. On the way, they encounter a wonderful gallery of friends and enemies, of every degree of humanity and none, ranging from the divine to the diabolical.

I came to this book as a devout fan of E. Hoffman Price's similar tales (*The Devil Wives of Li Fong* and *The Jade Enchantress*, both Del Ray paperbacks) and of Robert Van Gulik's immortal Judge Dee. I was prepared to find a book that fell well short of their standards. I have seldom been so delightfully disappointed.

Tim Powers says he doesn't do sequels. Indeed, there isn't much more his characters can do at the end of *Dinner at Deviant's Palace*. The Alien Menace has

been defeated (provided that the hero and heroine are willing to devote the rest of their lives to making sure he stays defeated). The post-holocaust society (a fascinating mixture of punk decadence and hard-scrabble survivalism) can go on with no more danger from the cult of Norton Jaybush.

What happens on the way to this conclusion, however, adds up to a first-class adventure story, with a nice balance of realism and romanticism. With this book, Powers became the first two-time winner of the Philip K. Dick Award, and I wasn't particularly surprised.

Two novels that look modest are absolute treasure troves once you start reading.

Melissa Scott's *A Choice of Destinies* gives the alternate-world novel a new twist in telling the story of an Alexander the Great who left an enduring empire behind him. Apart from "Interludes" from later centuries, the whole book is the story of the alternate Alexander and how he laid firm foundations for his empire by turning west and conquering Rome.

Scott has done what some might call cheating, giving Alexander a Macedonian marriage and son that his historical counterpart lacked. She has also put the Theban Sacred Band into Alexander's army in Persia—a historical license which produces some of the most powerful scenes in the book.

But these are ultimately quibbles. What Scott has really done is write a superb historical novel, full of intelligent characterization and brilliantly-detailed battles—a novel from another time-line than ours.

I suggest that only a miracle will produce a better first novel this year than Lois McMaster Bujold's *Shards of Honor*. I will also be surprised and outraged if she isn't a Campbell Award nominee.

The novel can be read and enjoyed as a fairly straightforward story of two enemies in a future interstellar war who fall in love. But Aral Vorkosigan is a warrior aristocrat of the authoritarian Barrayaran Empire, while Cordelia Naismith is a reluctant heroine from the Betan

Survey Service. The gap between them should be greater than the light-years between their home planets—but Bujold shows how they bridge that gap.

In the process, she tells a story that succeeds at every level—pacing, characterization, action, political intrigue, world-building, and language. Any author who begins a novel with the two protagonists slogging across two hundred kilometers of hostile wilderness on a diet of dried oatmeal and synthetic blue-cheese dressing has little to learn about hooking the reader. Any author who turns phrases like, "They think they're the wave of the future, but really they're just sewage flowing downhill," can teach many allegedly distinguished colleagues a good deal.

Two forms of space-advocacy, one fictional, one only reading like sf.

Melinda Snodgrass comes to straight sf from a background that includes a law degree, a number of excellent romances, and a bestselling *Star Trek* novel (*The Tears of the Singers*, from Pocket Books). She tells the story of 21st-century lawyer Cabot Huntington, appointed Justice of the 15th Circuit Court, with jurisdiction over the colonies in space.

Unfortunately, it turns out that he has been sent to bring the space colonies back under the authority of a repressive and paranoid Earth. When he discovers this, he switches sides, using all his legal skill to keep the colonies free.

Snodgrass has some trouble with dialogue and occasionally leaves a scene undeveloped, but offers brisk pacing and intelligent speculation about space settlements and their legal institutions. The first of a trilogy, *Circuit* is a welcome addition to social-sciences sf.

Bantam Books has brought out the report of the National Space Commission in a large-format paperback, lavishly illustrated with the art of Robert McCall and other stalwarts of futurology. What gives one a chill reading the book is that here we have a sane and sober group of government appointees laying out a pro-

gram for space exploration that overflows with sf concepts. The moon and Mars are to be settled, the solar system explored, the asteroids mined . . .

A prophecy? One would like to think so. Certainly a good signpost, to a road we should walk sooner rather than later.

AMERICA: A SECOND-CLASS SPACE POWER

And now for a little excitement. By sheer chance we have the opportunity to present two almost diametrically opposed assessments of the threat presented to the United States by the Soviet space program. Both authors have reviewed the other's article; both remain comfortable with their own conclusions—and find the other's deeply flawed.

Next issue (in which we will have changed our name from Far Frontiers to New Destinies) both articles will receive point-by-point rebuttals. May truth and justice triumph.

—JPB

AMERICA: A SECOND-CLASS SPACE POWER

G. Harry Stine

When the Space Shuttle Orbiter OV-102 *Challenger* was destroyed on January 28, 1986, the American people had driven home to them that the United States of America is a second-class space power. The USA is likely to be in very deep trouble as a result—trouble that stems primarily from the philosophy, foreign policy, and military doctrine of a first-class space power: the Union of Soviet Socialist Republics.

Furthermore, the USA is likely to remain a second-class space power for at least another five years and possibly longer. How much longer may depend on what the USSR is really doing in space.

This happened once before. The Soviet Union upstaged the United States on October 4, 1957 by launching *Sputnik-1* while Americans were crowing to the world about Project Vanguard, "the world's first artificial Earth satellite" which hadn't been launched yet. That was a long time ago. Many people reading this weren't born yet. America got sputniked because President Eisenhower thought that \$125 million was too much money to spend for a satellite launch project thus, Project Vanguard didn't have political support,

which meant that in this country it didn't have popular support and therefore the politicians, reacting to public moods and desires, didn't back it either.

Eisenhower also did something that Nikita Khrushchev didn't. Ike separated the military from the civilian space activities. The American military space program would continue to be a highly-classified, secret activity while the civilian space program would operate with a television camera staring over its shoulder at all times. Soviet leaders never did this because of their basic Russian, Marxist, and Lenninist philosophical foundations.

In the Soviet Union there is practically no way to separate a military activity from a civilian activity because the entire Soviet culture and economy is established on a wartime footing. A factory that makes Fiat/Ladas also makes military trucks. For example; the Ladas are exported and most of the trucks go to the Red Army, the rest to a defense reserve pool where they're used by agricultural communes and state factories. The Soviet Union has had a system of military conscription continuously since 1939, and nearly every male in the Soviet Union serves three years in one of the armed services. With about six million men under arms at any given time, some western observers have expressed the opinion that the Soviet military machine is nothing more than a huge training camp where at least one-third of the troops are always new recruits.

"Bringing up a future soldier begins, if you please, with childhood," was the view expressed in a leading Soviet military journal in 1972—which is in the post-SALT period, by the way. Since the fall of Khrushchev, there has been an increasing emphasis on the military for young children. What do young Soviet boys play? "Germans and partisans." Children's books have taken full advantage of "the time of adolescent dreams" to indoctrinate young people with the glory and honor of becoming a soldier defending the motherland. A book for pre-school children is entitled *We Pick Up New Rifles*, with illustrations showing children being issued rifles and repelling the enemy. Another book features a

twelve-year-old general to inspire young boys into dreaming of ascending through the ranks of the Red Army.

In the first elementary grades, teachers are directed to begin preparing the child for later military service. Soviet boys and girls between the ages of eight and fifteen must be members of the Young Pioneers—which some well-meaning Americans have mistakenly equated to the scouting movement in other countries—where they learn to march, handle firearms, stand guard duty at important war memorials, and become thoroughly acquainted with the roles and missions of the various Soviet armed forces, including the KGB Border Guards and Internal Troops. Beyond the Young Pioneers is the *Komsomol* organization for older teenagers.

Each summer, about 15 million Young Pioneers take part in realistic war games called *Zarnitsa* while about 7 million *Komsomols* participate in their version called *Orlenok*.

As a pilot and a model rocketeer, I'm especially familiar with a Soviet organization known as DOSAAF which stands for The Volunteer Society for Co-operation with the Army, Aviation, and Fleet. Want to build a model airplane or a model rocket in the USSR? You'll do it only under the close supervision of the local DOSAAF group. Same goes for amateur radio (tightly regulated) and other technical hobbies and sports such as flying, soaring, parachuting, ballooning, motorcycle racing, and even model railroading. From my own experience, the Soviet and Warsaw Pact aeromodelers are very good indeed (as a glimpse at the international record book will show); they should be because DOSAAF provides them with excellent facilities. As for Soviet pilots, the USAF knows that they're well-educated, highly-trained, strongly motivated, but operate under nearly absolute ground control. Their doctrine demands they abort a mission or even an attack if ground control contact is lost. The Soviets don't encourage a lot of personal initiative and independent action on the part of their pilots; when the reins are loosed a tad, Ivan files his Foxbat to Japan.

Note that nothing has been said thus far about computers. The USSR has its version of the Apple (the Red Apple?) and other western computers. They will be found in offices, bureaus, factories, military installations, schools, Young Pioneers' meeting places, and DOSAAF club houses. They will not be found in Soviet homes. As the Soviet Union becomes progressively more computerized in order to compete in the world, note carefully the clever ways the Party will manage to retain complete control over computers and their use just as they do over the people.

The point here is that the Soviet Union, in spite of its leaders and diplomats in their tailored three-piece suits and their stylish (to them) wives, is an entire culture of 272 million people geared to a militarized existence on a continual near-war footing. They are ready to defend the state. Why? What have they got that anyone else would want? They don't have any exports to speak of except caviar and vodka, and the natural gas they ship from Siberia isn't a critical energy source for Western Europe. They have no tourist trade; in fact, their own people want to get out. The Soviet citizen is well educated, technically proficient, hard-working, and able to withstand the worst privations. As an American businessman recently said, "I'm glad they're not capitalists! Think what competition they'd be if all those human and natural resources were ever applied to international trade and commerce!"

The Soviet Union only separated its military and civilian space programs when in early 1986 it created *Glavkosmos* SSR, which translates as The Main Administration for Development and Use of Space Technology for the National Economic and Scientific Research. That says nothing about *Glavkosmos* SSR being a civilian space program. The space program of the Soviet Union was and continues to be overwhelmingly devoted to military purposes.

In 1985, the USSR made ninety-eight space launches carrying one hundred and nineteen payloads. Only 2 of these were purely scientific missions—*Kosmos-1645* and

Prognoz-10. They launched three *Molynia* comsats and eight low-orbit comsats, two manned *Soyuz-T* spacecraft and three *Progress* resupply ships for *Salyut-7*. The rest of the payloads were military satellites. In 1985, for the first time, there was a Soviet recon satellite over every part of the world at any given moment. In the same year, the USSR replaced its entire early warning satellite system. This is a peaceful space program?

Initially, both the USA and the USSR went into space for military purposes. In the period 1946-1957, the American rocket program was carried on by the military services and most of the high-altitude rocket research had to do with radio propagation and other characteristics of the upper atmosphere. They were working on the development of radio communications, the technology that, beginning in the early 1900s, was the first whose research and development was primarily funded by, carried out by, or done under academic contract for the Department of the Navy and the War Department.

Following World War II (the Soviet's Great Patriotic War), the USSR opted not to build an intercontinental bomber fleet (although they did build enough big airplanes to cause the USA to spend billions on an air defense system that was never used and that has now been dismantled). The USSR went for the intercontinental ballistic missile, flying the first one in August 1957. The very same type of vehicle, the Korolev-designed R-7 Sem-yorka, was used to place *Sputnik-1* in orbit in October 4, 1957. The purpose of *Sputnik-1* was to measure the radio transmission and environmental characteristics of the upper atmosphere through which the thermonuclear warheads of the Soviet ICBM would have to pass.

Nikita Khrushchev also understood the propaganda value of space flight spectacles. The early Soviet feats were scheduled around important political and diplomatic affairs. The only American politicians who seemed to understand this and who were in a position to do something about it were President John F. Kennedy

and Vice President Lyndon B. Johnson. Kennedy, on Johnson's recommendation, established the American goal of the manned lunar landing. The USSR, not to be out-done, established their own manned lunar landing program and believed they'd be able to beat the Americans because of their massive lead in large boosters.

But there were some huge disasters in the Soviet space program—the Nedelin catastrophe of October 21, 1960 when the launch vehicle blew on the pad and killed the cream of the Soviet rocket cadre; the death of cosmonaut Vladimir Komarov on the Soyuz-1 mission, and the enormous failure of the heavy-lift Type G launch vehicle, their Saturn 5, on July 4, 1969. Nobody remembers the AP release from Moscow in December 1968 which reported that the Soviets had officially cancelled their manned lunar landing program.

The Soviet Union redirected its space program toward Earth-orbit. We don't yet know the true nature of that program and can only make educated guesses based on facts that leak out from time to time or are ferreted out of the Soviet, British, and even American literature by such Soviet space watchers as Charles P. Vick, James M. Oberg, and Arthur Bozlee. The Soviet Union has a long-term commitment to space. But, on the basis of historical evidence, it's extremely difficult to rationalize that the Soviet-manned space program is being conducted for totally peaceful purposes.

The Soviet Union understands the principle of the high ground of space, is seizing it now, and undoubtedly intends to use it.

It took me over a year to obtain, but I finally got a copy of *Soviet Military Space Doctrine*, publication DDB-1400-16-84, published by the Defense Intelligence Agency on August 1, 1984. This analysis of overall Soviet military doctrine led DIA to the following statement:

"The Soviet Armed Forces shall be provided with all resources necessary to attain and maintain military superiority in outer space sufficient both to deny the use of outer space to other states and to assure maximum space-based military support for Soviet offensive and

defensive combat operations on land, at sea, in air, and in outer space."

The Soviets have also announced that they're going to Mars—unmanned in 1989 and manned by 1992.

With the stable of new launch vehicles the Soviets are just now beginning to fly, they can hold the high ground of Earth orbit and go to Mars, too, just as they used their R-7 ICBM as their first space launcher and, in fact, are *still* using it as the A-2 Soyuz, Progress, and limited-lift interplanetary launcher today, 29 years after they first flew it. (Where are the boosters we first flew in 1957? We'll see shortly.)

By early 1986, the USSR had made three suborbital test flights of the first of its new launch vehicles, the medium-lift Type J or SL-X-16. The latest numbers from DIA indicate that the Type J will place 15,000 kilograms in a 180-kilometer orbit, making it roughly equivalent to the USAF Titan 34D-7.

For several years, photographs taken by Landsat and even with hand-held cameras by space shuttle astronauts have shown a huge launch vehicle on the pad at Tyuratam using one of the two repaired and revised launch complexes built for the Type G vehicle in 1968-1969. One of these was levelled by a "malfunction" of the first Type G at or shortly before launch on July 4, 1969. In fact, some of the scorch marks on the ground can still be seen in the space shuttle photos. It has taken the Soviets sixteen years to re-design this heavy-lift launch vehicle. Charles P. Vick, who made a detailed design study of the old Type G on the basis of a drawing of the gantry crane and service tower published in a Soviet book, believes the New Type L will be capable of orbiting a payload up to 10 meters in diameter and weighing up to 200,000 kilograms. The Type L HLLV will probably have flown by the time this reaches print, thus giving the Soviet Union a payload lifting capability for space stations and Mars trips that the United States once had and demolished, leaving three unused Saturn-5s laying on the ground to rot.

The USSR has also flown several miniature shuttle-

type vehicles that some American observers are calling a spaceplane. They claim it will be a personnel shuttle to and from the space station. However, when thinking about Soviet matters, it's often helpful to try to think like the Soviets, which is extremely difficult for Americans. One must become familiar with their technological history, especially in their aerospace industry, as well as with how they design, develop, build, and operate their airplanes and spacecraft. In Soviet terms, it may turn out that the Soviet spaceplane isn't what we think it is. The three that have been flown thus far would be absolutely wonderful for transporting five-foot midgets back and forth into space; it isn't very large. Soviet cosmonauts, including General Alexei Leonov, have flatly stated that the spaceplane isn't a scale model. American aerospace engineers are quick to point out that flying scale models of winged gliding re-entry spacecraft isn't the most reliable way to get data that can be scaled-up. Some American-Soviet space watchers, primarily Vick and Bozlee, claim that the Soviet spaceplane may be a hypersonic unmanned orbital anti-ship weapon. Frankly, no one in the West knows what the hell it really is.

The same cannot be said for the Soviet shuttleski. Two orbiters have been photographed at the Ramenskoye flight test center outside Moscow. Satellite recon photos have shown the orbiter mounted atop a Myasishchev M-4 Bison converted jet bomber roughly equivalent to the American B-52 and about the same vintage. We even know they ran the Bison/shuttleski combination off the side of the Ramenskoye runway into the snow and mud. Again, Charles P. Vick has thoroughly analyzed all available unclassified information about shuttleski. It's slightly smaller than a space shuttle Orbiter. However, some of us are wondering how the Bison can possibly carry it because it would have to weigh less than 120,000 pounds. An empty US Orbiter weighs roughly 140,000 pounds. Conclusion: what we saw on satellite images may have been a light-weight shuttleski aerodynamic test shell (*Enterpriseski?*) mounted on the Bison. Or the shuttleski—possibly a product of the

Tupolev design bureau's extensive experience with large supersonic delta-winged vehicles such as the Tu-144 SST—may come from the factory stripped so the Bison can carry it to Tyuratam, provided the old bomber is air-refueled along the way. Or maybe the final shuttleski orbiter will be carried on the new Antonov Condor transport which is about the size of the Lockheed C-5A Galaxy.

At Tyuratam, a new runway several kilometers long and nearly a hundred meters wide has been constructed near the Type L launch vehicle complex. It is aligned with the nominal 57-degree orbital track of most manned launches out of Tyuratam. This is indeed an airplane runway and it has been used as such. The runway tire scrub-marks can be seen even on the hand-held camera frames from the NASA space shuttle missions.

The Soviets do have a large reusable space shuttle vehicle, but it isn't exactly like NASA's and it probably uses some of the components of the Type L launch vehicle. This would be perfectly in concert with Soviet practice.

Launch date: spring-summer 1987. Yes, it's a guess. Tell me I'm wrong. Please tell me I'm wrong about all this new Soviet space hardware!

Why? Because with the *Challenger* disaster throwing the entire American space community into turmoil, the Soviets now have a better chance than ever before to seize the high "ground" around the Earth and to use it. How they can do this and how they could legally keep the United States military and commercial activities under control, as well as denying anyone permission to build, much less live, in a space colony? This was discussed in my book "Confrontation in Space," published in 1981, which was thoroughly read in the Pentagon and in most of the advanced military colleges in the United States. It was a small printing, almost totally scooped up by Pentagon types, and the book has not been reprinted because the publisher has since been purchased—for its text-book line, not its trade books, which were left to languish.)

The Soviet Union obviously cannot take control of

the high ground overnight. That's much too big a job and—although they do bean-counting differently than we do—it's going to cost them money. But, given five years in which the United States doesn't wake up and get cracking, they could pull it off. What can we do about this? What do we have to do? As always, there are options and alternatives. Some of these were mentioned in my article *The Wake of the Challenger*. However, a few months have passed since that was written and the picture is clearing up in some places and becoming more cloudy in others.

The very first thing that's certain is the building of a replacement *Challenger* Orbiter. Call it OV-105, the legendary fifth Orbiter. It turns out that Rockwell International, builder of the Orbiter at Palmdale, California, had received a NASA contract to make spares for the existing Orbiters after the OV-104 Atlantis was completed. According to *Aviation Week and Space Technology*, there are enough parts at Palmdale to build 40% of an Orbiter. But it's critical to know which 40% and for how much money? What does a space shuttle Orbiter cost?

According to the best data I was able to obtain from Rockwell International, it would cost between \$2.5 billion and \$4.0 billion, depending on what spares are already in inventory, whether or not the various subcontractors still have their original tooling, and whether or not some of the original subcontractors are still in business. If new subcontractors must be found and qualified, the higher cost figure holds.

Question: the space shuttle Space Transportation System (STS) has shown itself to be a flawed system; it killed seven people. So, goes the logic, why should we send good money after bad? Run out the remaining space shuttles and in the meantime get busy building the follow-on system which will be safer (maybe).

Two important factors rear their ugly heads here:

1. The remaining Orbiters are wearing out. They were designed to last for 100 flights, but many engineers believe there is so much airframe fatigue that

they won't last for 50, and some people say, 25. For example, according to unconfirmed rumors, the *Challenger* itself, the Orbiter with the most flights and therefore the highest time on the airframe, was already beginning to show evidence of microcracks in the wing spar carry-through structure. The Space Shuttle Main Engines (SSME) in the tail of the Orbiter were supposed to last for 50 flights without an overhaul; at the time of the disaster, the SSMEs were being completely overhauled after every flight. The TBO (time between overhaul) was so much shorter than anticipated on some components that Orbiters just entering processing after a flight became fair game for cannibalization—steal the needed part and put it on the bird about to be rolled to the pad, because maybe by the time the cannibalized Orbiter got ready to roll to the pad, the replacement part would be available or could be swiped off another incoming Orbiter. (That's no way to run an airline, and certainly no way to run a space transportation system!)

2. From the moment the signal is given to go, 36 months will elapse before OV-105 rolls out the Palmdale factory door ready to be airlifted to the Cape. Thus, no matter what we do, we're stuck with a space shuttle system that is going to operate at 60% of capacity for the next three years. Some people have said 75% of capacity. But the mission model and the schedule was tailored to a 5-Orbiter fleet; with 4 Orbiters, the system was already working at 80%!

This threatens to leave us with zero space transportation capability within ten years. If we assume that there will be no future accidents and no more lost Orbiters; and that the space shuttle fleet will start flying again in July 1987, we are left with the following:

SCENARIO #1: 3 Orbiter Fleet and OV-105 is not built:

25-Mission Orbiter Life:

A. At 12 missions per year, fleet worn out October 1993.

B. At 18 missions per year, fleet worn out September 1991.

C. At 24 missions per year, fleet worn out September 1990.

50-Mission Orbiter Life:

A. 12 missions per year, fleet worn out December 1999.

B. 18 missions per year, fleet worn out December 1995.

C. 24 missions per year, fleet worn out October 1993.

SCENARIO # 2: 3 Orbiter fleet 1987-1988-1989,
OV-105 operational July 1990:

25-Mission Orbiter Life:

A. 12 missions per year, 3 original Orbiters worn out October 1994, OV-105 has 12 remaining missions in lifetime.

B. 18 missions per year, 3 original Orbiters worn out September 1991, OV-105 has 15 missions left in lifetime.

C. 24 missions per year, 3 original Orbiters worn out by 1990, OV-105 has 3 missions left.

50-Mission Orbiter Life:

A. 12 missions per year, 3 original orbiters worn out February 2003, OV-105 has 10 missions left.

B. 18 missions per year, 3 original Orbiters worn out August 1997, OV-105 has 32 missions left.

C. 24 missions per year, 3 original Orbiters worn out October 1994, OV-105 has 26 missions left in lifetime.

In short, if the Space Transportation System is used for 18 missions per year, which is 75% of the originally-planned use-rate, it will be worn out sometime between 1991 and 1995, even if no other Orbiters are lost (and does anyone want to take bets on that?). If OV-105 is built, the original Orbiters will still wear out between 1991 and 1997 at the 18-mission use-rate.

Acting NASA Administrator Graham told Congress

that the Space Station cannot be built with a 3-Orbiter fleet. Even if the Space Station could be re-designed to be less extensive than originally planned and capable of being put up with a 3-Orbiter fleet by 1994, it would be accomplished with the last gasp of the shuttle fleet. The Orbiters may be worn out just when they're needed to service the Space Station.

It looks like we can say goodbye to the Third Industrial Revolution, at least insofar as the United States is concerned. Space transportation is absolutely essential and critical for space industrialization and commercialization, as we've been telling people for at least the last 12 years. But everyone has blithely believed that the NASA space shuttle would be widely and openly available to commercial users. It isn't any longer. Others have priority.

The Department of Defense has payload bumping rights on all shuttle flights and is already sweating about getting new recon, surveillance, communications, and weather satellites up there for national defense. Should anyone object to DOD bumping them, that person should be reminded that if the United States doesn't have a defense program, it won't make any difference whether it has a space program, much less a rip-roaring profit-making space commerce sector.

This doesn't take into account use of the shuttles for experimentation, development, or deployment of whatever space-based equipment is initially put up there for SDI, the strategic missile defense of this nation and the free world. Even before the *Challenger* explosion, the Strategic Defense Initiative Organization had booked a shuttle launch every year until 1992.

The United States, by counting on the federal government to do the job, and by letting politicians and bureaucrats hack away at the program for more than 17 years, has bet its whole future on a single space transportation system which has prove inadequate. But any of us who had the temerity to say that before January 1986 were considered to be fools who didn't understand the situation.

Can we salvage STS? Perhaps, if we work fast and are willing to bite the bullet and spend the money. But STS should be considered only as an interim system. STS is full of failure modes, and we've probably found only the first of them. It's expensive; no commercial outfit could run the system and break even, as NASA discovered when it went looking for commercial operators. And it's risky as every financier and venture capitalist thus far approached has said.

If NASA builds OV-105 and gets it on line, what happens if we lose another Orbiter? Back to January 1986! So how about building a sixth Orbiter, OV-106 as insurance to protect what has grown to a \$25 billion investment? That will cost us another \$3 billion or so. But that isn't a complete answer. It will take 60 months to deliver OV-106 because only one assembly bay is left in the Palmdale plant; the other has been taken over for Rockwell B-1B production.

Another factor limits the STS system: processing and launching facilities. The Cape has two launch pads and can handle only three Orbiters. Vandenberg has a single pad and can handle only one shuttle at a time because the vehicle is stacked on the pad, not in a VAB, and ties up the pad for more than a month at a time.

And, until there are a *lot* of fixes made, the astronaut corps has flatly said they will land Orbiters only on the dry lake bed at Edwards Air Force Base. This means that each Orbiter has to be air-lifted back to either the Cape or to Vandenberg. Only *one* aircraft is outfitted to do this, NASA 904, the converted Boeing 747-100 purchased second-hand from American Airlines. Bust or bend NASA 904, and the STS system is out of operation for at least a year until another 747 can be located and modified.

The United States of America has put all its eggs into one space launching system with no contingency plan. And we got caught. I'd known the situation was bad, but it didn't dawn on me how bad it really is until I wrote this!

So much for the good news.

Although NASA has recommended resuming shuttle flights by July 1987, other experts advising the Presidential Commission investigating the *Challenger* disaster have reportedly recommended an in-depth program to fix the SRBs that would delay shuttle flights for 30 months, in which case shuttle flights wouldn't resume until July 1988. The best bet at the time of this writing is a parallel program that gets the STS back in operation as quickly as possible with a quick-fix on the SRB field joints plus conservative red-line do-not-exceed values for launch temperatures and wind shears aloft. Improved fixes would then be phased into the program as they become available. If the 30-month in-depth fix program is undertaken, the resulting delay will probably deal the shuttle right out of the game insofar as commercial payloads are concerned. STS users will look elsewhere for other launch vehicles. As a matter of fact, an 18-month delay—which is currently anticipated—is already forcing customers to look around . . . frantically, in some instances.

Some scientific, exploration, commercial, and defense payloads can be shifted to expandable launch vehicles. And they probably will be. But what's the situation with those?

The major medium-lift expendable launch vehicle (ELV) in the US stable right now is the Titan-34D, an improved Titan-IIIC which the U.S. Air Force has been operating for over twenty years. The USAF currently has six Titan 34Ds on hand and ten, more powerful advanced Titan 34D-7s on order. The Titan 34-D has been grounded since 1984 when one blew up shortly after launch. The post-*Challenger* schedule called for the last 34D to fly in 1988. With reduced STS flights available for DOD missions, that will happen sooner as shuttle payloads are shifted to Titan-34D. The Titan 34D-7 is currently in the final design stage, and no one knows when it will be ready to fly. The Titan 34D can put 32,000 pounds in a low-inclination Low-Earth Orbit

(LEO). This payload is cut about in half when polar orbits are required.

However, the latest attempt to fly a USAF Titan-34D ended in failure when it blew up a few seconds after launch on April 18, 1986. Thus it seems that Titan-34D and Titan-34D-7 are effectively out of the running as launch vehicles until at least mid-1987 and perhaps longer.

The USAF also has about fifty recently retired Titan 2 ICBMs on the shelf. This is the same booster that launched the 8,200-pound two-man NASA Gemini spacecraft into orbit from the Cape. These ICBMs are more than twenty years old. The USAF plans to convert twelve for use as ELVs able to boost 1,600-pound payloads into polar orbit.

All the remaining Atlas/Centaur launchers left are booked, and the production line has been shut down. Convair is thinking about re-opening it before the tooling and jigs get lost or otherwise disposed of. When production lines are shut down, the tooling and jigs needed to assemble large vehicles are usually moved out to the boneyard because they occupy an enormous amount of factory floor space usually required for another program. Out in the boneyard, the jigs and tooling have a tendency to get picked to pieces by people pilfering them for parts and material. Sometimes the jigs and tooling are sold because, even at scrap metal prices, they bring in a lot of money. The expense involved prohibits most American aerospace production lines from being put into mothballs. As we'll see this isn't necessarily so in the Soviet Union.

The reliable workhorse of the American ELV stable for the last quarter of a century has been a modified, stretched, up-graded, and continually improved version of the old Thor IRBM which is called Delta. Eleven Deltas remain, and they all belong to someone. The production line may already be closed. Subsidized Shuttle and Ariane launches prevented McDonnell-Douglas (the manufacturer) and TransSpace Carriers (the mar-

keting and sales firm) from finding enough commercial buyers to keep the line open.

The EuroSpace Ariane launch vehicle was booked solid through 1992 within weeks after the *Challenger* blow-up. Furthermore, in April 1986, the Arianespace operating organization increased Ariane launch prices by 20%, a move they claim isn't due to market demand but to changes in the value of the dollar.

The People's Republic of China has three Long March ELV types which are being marketed in the United States by Space Vector Corporation in Northridge, California. These are equivalent to the Delta and the Titan, and the Chinese now have a liquid-hydrogen upper stage that will loft 8,000 pounds into geosynchronous orbit.

At the time of this writing, the Japanese cannot offer launch services to foreigners with their current H-1 launch vehicle, a license-built Delta, because of the licensing covenants. But the new, all-Japanese H-2 ELV is due to fly in 1992, and the Japanese can and will offer launch services with it.

What about the USSR? It took its Type A-2 or SL-4 Soyuz/Progress launch vehicle, an up-graded version of its original R-7 Semyorka ICBM, out of production last year and is using up the inventory. The SL-4 production line was shut down but wasn't dismantled; it was mothballed so it can be re-opened at any time. The Soviets can afford to do this. Their money types count beans differently. The Soviets may take advantage of the shortfall in American launch capability by offering the SL-4 which can put about 15,000 pounds in LEO. Furthermore, eleven SL-12 Proton launch vehicles come off the Soviet production line every year, the newer ones as SL-15s with high-energy liquid-hydrogen upper stages. The Soviets have already offered commercial launch services on the Proton at a price per pound 20% less than the NASA space shuttle, payment in hard currency, please. The USSR has a stable of light-lift and medium-lift launch vehicles converted from the early Sandal IRBM and the Skean ICBM, and may also offer

these as commercial ELVs. All of the above-mentioned Soviet launch vehicles represent old technology based on obsolete IRBMs and ICBMs that were long ago taken out of operational military service. They also have a totally new stable of launch vehicles coming along for their own exclusive use. These new vehicles will permit them to retain their lead while they make hard currency with their obsolete boosters. The Soviet SL-X-16 or Type J made three suborbital test flights in 1985 and will become operational in 1986; it is equivalent to the USAF Titan-34D in payload capability. And the Type L heavy-lift ELV, the Saturnski, is probably coming along this year and should be able to loft 10-meter diameter payloads weighing up to 440,000 pounds. *Bojemoi!*

Ladies and gentlemen, America is now a second-class space power behind the Soviet Union and is rapidly losing second place to the Europeans. By the end of 1986, the United States may even be behind Japan and the People's Republic of China. Not only are the Soviets free to seize the high ground of orbit in accordance with their military doctrines, but other nations are already seizing American high trade.

Can we get out of this mess? Can we regain our status as a first-class space power? Can we become a spacefaring nation?

Yes, but it will take at least five years, cost at least \$10 billion, demand a complete and thorough house-cleaning inside NASA, require the development of something called an aerospaceplane, and demand that some clever way be found to unleash the engines of private enterprise for the production of new private launch systems.

We've been through all the time and cost factors, and it should be pretty obvious by now that NASA needs a lot of things, if not a shake-up in management then certainly a re-definition of its mission. Whether or not this will happen is uncertain; there is nothing more difficult to change than a government agency, especially a large one with enormous inertia.

In his 1986 State of the Union speech, President

Reagan spoke about what he called the Orient Express, a hypersonic transport aircraft that would fly to Tokyo in 2 hours and would also fly into orbit. This concept has been under study for at least 25 years under various guises, names, and project codes. In fact, it can be traced back to the work of the Austrian space pioneer, Dr. Eugene Sanger, who did considerable research on the basic concept in Germany prior to and during World War II. What President Reagan was talking about is a USAF research project code-named Copper Canyon. It has since been re-named National Aero Space Plane (NASP) and humorously called the Gipper Clipper. It would be a hypersonic airplane that would also function as a space shuttle, because if you can go Mach-25 at 250,000 feet, you can go into LEO with the last gasp. Copper Canyon would take off from an ordinary runway, fly into space using airbreathing engines called aeroturboramjets which start off as rocket-powered turbojets, become supersonic ramjets, and turn into rockets. Aerojet General Corporation has revealed the concept of the engine. The fighter jocks who run the Air Force these days love Copper Canyon! Light the aeroturboramjets, suck the stick back, and blast into orbit fangs out and hair on fire! Congresscritters love it. So does the White House. But not NASA, the National Science Council, the National Security Advisor, or the non-USAF Pentagon rocket types. As of this writing, a monumental political battle is under way in Washington between the airbreathing gang and the rocket club.

Can Copper Canyon save us? Dr. David Webb of the Presidential Commission on Space says that for \$3 billion to \$4 billion—about what it would cost to build OV-105—we could have a small-scale proof-of-principle research version by 1989 with NASP another ten years beyond that. Maybe. NASP is loaded with new and untried technologies—propulsion and thermal protection, to name but two. Unproven technologies are those that have been tested in the lab but haven't yet been tried by a test pilot. They are usually full of bugs and rife with nasty little killers. To overcome this sort of

thing requires money and time. We don't have a lot of either. Throwing more money and manpower at a difficult and badly-needed program cannot ensure an earlier completion date. Just because a woman can have a baby in nine months doesn't mean that a baby can be created in one month by putting nine women on the job.

We have five years at most to straighten out this mess and re-establish a powerful American presence in space. The remainder of the NASA Orbiter fleet can't do it; we've seen that. Putting old ELVs back into production brings us to where we were ten years ago, and those ELVs are re-worked ICBMs intend to lob warheads on targets, not give gentle rides to put payloads in space. Copper Canyon simply cannot get on line fast enough because of all the unproven technology involved. The earliest estimate of when we might have NASP operational as a space launch system is 1999. With any luck at all, the Soviets may then allow us to fly it into space . . .

"What do you mean, allow us to fly into space? The Soviets are co-operative in space ventures! They let our scientists watch their Vega probe fly past Halley's Comet, didn't they? They've told us they're going to Mars and they've even invited us along, haven't they?" Yes, they allowed American scientists to visit Moscow and sit around a room full of TV monitors as Vega boomed past Halley's Comet. This was a great PR bit, especially since the United States had opted not to do a Halley fly-by because of the expense involved. The USSR wasn't about to pass up the chance to rub this in using spokesmen of the internationalist community such as Dr. Carl Sagan. As for inviting us to go along on their various Mars missions, the Soviets have said they'd be happy to take our black boxes with them. For many planetary astronomers, faced with at least five and maybe even ten years of greatly reduced space activity, participating in the Soviet Mars missions could be a bottomless well of funding that would help keep their grad students in grants and their observatories staffed while they en-

gaged in all that wonderful international cooperation with the Soviets.

A serious question lies in the minds of many Soviet space watchers and others. Is the proposed Soviet Mars mission literally a red herring intended to distract our attention while something else is going on? Do the Soviets really intend to go to Mars? Can they actually pull it off?

They can and probably will go unmanned to Phobos in either 1989 or 1991. At least they'll try, probably with at least two and maybe three spacecraft, because they've attempted to up-stage us, managed to succeed in doing so, and must now put up or shut up . . . and they don't like to lose.

If their new stable of ELVs and the shuttleski fly by late 1987, they will have the lift capability to go manned-Mars. They claim they're going to do it in 1992. They may be able to, depending on how much lift capability they have and how good their on-board life support systems are. The Soviets have a closed ecological life support system operating on the ground. They've been working on this for the last 25 years, and are far ahead of the USA in this area. But getting that system to work reliably in space is something else.

Many serious students of Soviet space programs believe that the Soviet Union can't or won't mount a successful manned-Mars mission before the 1999 launch window.

However, the Soviets may certainly have the capability in the 1990 time period to control and deny access to LEO. And, if they get that, we are in deep yogurt.

If Copper Canyon/NASP/Gipper Clipper probably can't save us, what can? The answer is private enterprise.

It's a last resort, but it's the one we should have counted on in the first place because it is and always has been the greatest strength of this nation. However, since 1980, NASA has carried out a highly successful and often vicious program intended to eliminate any and all competition from private ELV companies. This has been fully and completely documented in the pages

of *Far Frontiers*. As a result of NASA's monopolizing activities, the private ELV industry is staggering on the ropes. Nor has NASA stopped using these tactics since the *Challenger* disaster.

For example, TransSpace Carriers, Inc. (TCI), the Delta marketing company, signed an agreement with NASA in 1984 giving TCI exclusive marketing rights to the last eleven Deltas. The agreement expired and was extended several times. When NASA needed to cannibalize some spares from these eleven Deltas for the boosters to be flown for SDIO, TCI consented to amend the agreement to that effect. After the *Challenger* explosion, NASA unilaterally re-interpreted the amendment as giving NASA complete control over all eleven remaining Deltas. NASA refuses to give them back unless TCI can show customers contracts, binding contracts with McDonnell-Douglas, and final financial agreements. It's nearly impossible for TCI to obtain these because customers, vendors, and financiers have no assurance that NASA won't continue to re-interpret the amendment. Since NASA is also in the business of launching commercial payloads and has a bunch of stranded commercial shuttle payloads that could be boosted on Deltas, it's unlikely that TCI will ever get the eleven Deltas back, much less come up with the estimated \$100 million needed to re-start the production line.

The various private aerospace contractors who know how to build space launch vehicles are unlikely to step forward with bold new ventures. NASA and the federal government are still their largest customers, and one does not alienate one's biggest account. The Curtiss-Wright Corporation, the world's largest builder of aircraft and piston aircraft engines in 1945, made the mistake (among others) of neglecting its lucrative government business after World War II, and dropped completely off the Fortune 500 list within ten years. This example has not been forgotten by today's aerospace contractors. Furthermore, when General Dynamics, McDonnell-Douglas, and Martin-Marietta tried to enter the space

launch business in 1980-1982 with their existing ELVs that had been turned over to them by NASA they were quietly visited by NASA officials who remarked that the NASA contracts then held by these contractors could be opened up for new bidding—in short, they could be taken away if the firms had the audacity to compete with NASA in the space transportation business.

How about the other companies in the space launch business—Space Services, Inc. (SSI), Pacific American Launch Systems, Truax Engineering, Third Millennium, Inc. (TMI), and American Rocket Corporation (ARC)? The SSI Conestoga is too small to handle any of the shuttle payloads. Pacific American Launch Systems is running into problems obtaining risk capital, in spite of a contract worth nearly \$280 million to provide and operate two Phoenix-E vehicles for Society Expeditions, Inc. The others are having difficulty raising equity capital. Why? Investors, venture capitalists, and financial institutions tell them, "We know nothing about the technology behind your proposal, so we're having it checked by independent experts." Where do the independent experts come from? NASA or the various NASA contractors, and you can easily guess that they will not give their enthusiastically support to anything that threatens the NASA monopoly, shattered though it may be at the moment. The private launch vehicle industry not only can't get off the pad, it literally cannot even get to the pad!

How about the government forming or encouraging the formation of huge mega-corporations to undertake the design and construction of everything from medium-lift ELVs to the huge heavy-lift launch vehicles that will be required in the 1990s? Two questions immediately arise: (1) Where is the money coming from in these days of continual cutbacks in all government programs? (2) Where is the incentive for NASA and even the federal government—to say nothing of the aerospace industry—to do anything like this when, in our crisis-motivated culture, *there is no clear and present danger that is obvious to any of our political*

leaders even though they know all the facts presented here and have the same if not better ability to put these facts together and see what a mess things really have become?

America is a second-class space power and will continue to remain such as long as the current thinking doesn't change.

The bad news: there is no indication that the true depth of the crisis is apparent.

The good news: we have a few years left to do something about it before other nations either seize the high ground of orbit and deny us access or simply out-compete us.

There are no easy answers to these problems. There is no magic formula that can be evoked to get us out of it. The federal government is not, will not, and probably cannot save our bacon and, in fact, it has done and continues to do nothing but put roadblocks and obstacles on the road to the stars. If NASA is changed so that it no longer behaves in a blatantly monopolistic manner there is still the Office of Commercial Space Transportation (OCST) of the Department of Transportation to deal with. However, it may be far easier to work with a monopolistic NASA and/or OCST than the KGB.

Very well, the situation is bad, and we can't count on the federal government to do very much to save it. What can we do, you and I?

Here's all us poor enthusiastic pro-space types. By rough count, there may be somewhere between 10,000 and 100,000 of use who have organized plus perhaps a million who are closet advocates. Most of us have our hands full trying to make a mundane living. Many of us are already doing what we can with what we've got. What more can we do? What can we do differently?

First of all, we *must* become better organized and do so quickly. We haven't done very well thus far. If the space advocates were as well organized as the Wisconsin dairy industry, we wouldn't be in this bind.

What have we done wrong?

We've engaged in too much dreaming. Far too many

space advocates are utopians. There's nothing wrong with this. Someone should be thinking about long-range planning. But very few have concerned themselves with what Robert A. Heinlein has continually pointed out: the most difficult job is getting from Earth to LEO, and the critical factor is the cost per pound of doing so.

We've gone along assuming that our government established by the people, for the people, and of the people is taking care of that difficult and expensive problem. As a result of the *Challenger* accident, various investigating committees and commissions as well as the national news media have brought to light the fact that, for the past 15 years or so, NASA has not been doing right by us and has not been carrying forward the grand dream it so wonderfully initiated in the 1960s. Like any other government bureaucracy, it has matured. In company with other government agencies, it has been dribbling away our heritage in an internal government battle for ephemeral bureaucratic turf!

Our children and our grandchildren could all be rich and free and happy with an entire solar system to explore and use and live in without any fear of limits to resources or energy shortages or insufficient room to grow and live . . . except for thousands of government bureaucrats who are more concerned about their pecking order, grade levels, and even their pensions! For the sake of these trivial things they have proven that they are ready, willing and able to doom generations yet unborn to lives of endless want, fighting over planetary scraps, and an even worse situation: an existence as bonded industrial slaves to a ruthless totalitarian government that has exploited its own population for seventy years and now stands ready to seize, hold, and control access to the solar system by free people.

No Dickensian factory worker in the "dark satanic mills" of the First Industrial Revolution faced a more stern and degrading master.

What must we do?

First of all, we must see to it that the federal government is not allowed to continue its monopolization of

space transportation or permitted to put all our eggs into one space transportation system. Let NASA run out the STS system and go back to what it's extremely good at doing: very advanced high-tech, high-risk research and development in areas where free enterprise is unwilling to tread just as their predecessor, NACA, did.

Secondly, get the bureaucrats out of the way of free enterprise. We don't yet know how well free enterprise will do in space or even if it will do better than the government. But on the basis of history, we should give it a try. It's worked well in the past and made America what it is today. Doing this means ordering NASA to stay out of commercial activities. It also means getting the United States to withdraw from the UN Treaty on space liability and getting rid of most of the recently adopted private space launch and payload regulations established by the Office of Commercial Space Transportation.

Dreams are fine, and we need the dreamers. But the times cry out for people who can do things. It is plain to see that we will not get into space by continuing as we've done in the past. If we Americans wish to be a spacefaring people, then we must start doing the things that made us Americans in the first place.

WINGED MYSTERIES— THE SOVIET SHUTTLES

While a great many "space watchers," this editor among them, believe that Soviet dominance of the high ground of space is both imminent and menacing, other Americans who believe their country is worth defending are able to draw different conclusions from the same set of facts. Roger Allen, for example, believes that one reason the Soviet effort remains shrouded in mystery is simple embarrassment over their paltry achievements.

Next issue (Remember: don't look for Far Frontiers; it will be the first issue of New Destinies) James Vick and Arthur Bozlee (mentioned in Harry Stine's article immediately preceding this one) promise a point-by-point rebuttal. Roger Allen stands by his own conclusions, and will rebut the rebuttal in the same issue.

—JPB

WINGED MYSTERIES— THE SOVIET SHUTTLES

Roger MacBride Allen

The Soviet space program plays the part of the big bad wolf in a lot of current science fiction—and in a lot of factual reporting as well. There have been endless warnings that the Soviet space juggernaut is going to overwhelm us. Their brand new hardware and relentless determination are going to win the heavens, the ultimate high ground, leaving the rest of the world helpless, at the mercy of their orbiting cosmic cities and space cruisers. Recent Soviet space successes—underscored by the *Challenger* disaster—have made these stories, both the fiction and the works of alleged reporting, more credible.

There's no question that the Soviet space program is impressive, and that it might be on the eve of some important breakthroughs. But even those breakthroughs, should they occur, will not put the Soviets irrevocably ahead.

But the notion that we will suddenly be eating the Soviets' dust is an article of faith for many people. The coming Red Age In Space, with its myriad space observation platforms, orbital battle stations, lunar colonies,

and Martian expeditions has become a sort of techno-folklore, a collection of good scary stories. Like all legends and bits of folklore, people believe because they want or need to. The primary reason Americans need to believe in the Soviet space behemoth is that it's a tried and true way to scare our own government into funding our space program. But folklore, faith in Soviet bogeymen, and real and imagined fears don't make for having an informed opinion. We are faced with the need for grave decisions about our future in space, and the time has come for a careful sifting of the evidence concerning the competition.

Is There Now, Or Has There Ever Been, A Soviet Shuttle?

On the Soviet shuttle, as with most of the Soviet space program, contradiction and confusion have facts and reality badly outgunned. Yet it is possible to dig through the misread clues, the miscalculations, the red herrings, the misleading and misled reports, and develop a reasonably complete understanding of what the Soviets are and aren't doing—and at the same time learn just how difficult it is to be sure of anything. The truth is hidden under a scrapheap of inaccuracies and wrong guesses.

Ironically, most of the misinformation and disinformation about the Soviet shuttle is of Western manufacture. Soviet statements on the subject contradict each other, but this probably reflects genuine changes in plans as much as deliberate attempts to deceive.

Their penchant for secrecy makes the Soviets easy prey for rumor. Just last April they reported on the 1961 death of cosmonaut in training, a death the world did not hear about for twenty-five years. The Russian refusal to report fully on their space program leaves the field wide open to reporters and researchers who must rely on tiny scraps of information and large doses of imagination to write a story.

The rumors about their shuttle have been going on for so long there is a little of the boy-who-cried wolf

about them—but the boy who cried wolf was telling the truth in the end. As Marcia Smith of the Congressional Research Service puts it, "Sooner or later, it's got to come true. And then all these people [who have been handing out shuttle stories that turned out to be wrong] can stand up and say 'See, I told you so!'"

Vintage Hardware

The Soviets could do with some new gear. Their current manned spacecraft, the Soyuz and its booster, were designed by Sergey Korolev, who died in 1966. In fact, the Soyuz booster is the same vehicle, with the addition of upper stages and some modernization, that launched the first satellite, *Sputnik-1*, into orbit in 1957! That booster is variously called the A-1, the SL-3 and RD-107, (or A-1 or SL-4 and RD-108 in another variant), and who knows what else. Since the Soviets don't generally release the names of their boosters, Western analysts take up the slack, and most boosters end up with three or four names. That booster, by whatever name, has been upgraded a bit over the years, but it has its limits: according to some reports, *Soyuz* must be launched with partially filled propellant tanks, because its booster cannot lift a fully loaded *Soyuz* into orbit. The Soviets have always flown in much lower orbits than American craft—in large part because of the limiting lifting power of their boosters.

Like its booster, the *Soyuz* has been upgraded. An improved variant called the *Soyuz-T* was introduced in 1979, and a further tweak-up just made its debut. However, according to Smith, *Soyuz* remains at about a Gemini level of technology—and the U.S. launched the last Gemini in 1966. The *Soyuz* continues to suffer from reliability problems, and failures crop up with unpleasant frequency.

Still, thanks in large part to their *Salyut* and *Mir* space stations, the Soviets have accomplished great things in their manned space program. They have set and broken the manned-space-flight endurance record over and over again. Soviet crews have remained in space for eight months at a time, overwhelming the American re-

cord of 84 days. In the whole of their manned space program, the Soviets have toted up well over 3,800 man-days in orbit—about three times the American figure. In spite of problems with their venerable space-craft, they have performed crew transfers, done repeated and routine resupply missions in orbit, performed important work in materials processing, and made daring on-orbit repairs and modifications to the *Salyut* space stations.

But enough on their old hardware: what about the new birds that are going to conquer the universe? So far, only one new design has made its official debut, the much ballyhooed *Mir* space station. *Mir* is not, contrary to many impressions, a revolutionary new craft. Except for its extra docking ports and a few other changes it is quite similar to the *Salyut*, and was launched on the same booster. It can be regarded as a more flexible model of *Salyut*, an incremental improvement and not a wholly new start.

That should not come as much of a surprise. While American designers are constantly eager to get on to next year's model before the bugs are completely out of the current machinery, the Soviet philosophy is to get everything possible out of a technology, maturing it, stretching it, working around its limitations in ways that are often ingenious. But sooner or later, the limits are reached.

Though many things should be easier aboard *Mir* than on *Salyut*, and it should accommodate a larger crew, there seems very little the Soviets could do with the *Soyuz-Salyut/Mir* program that they haven't done in some manner already. But the Soviets have frequently voiced ambitions—giant space stations, trips to the planets, vast projects of all kinds—that are simply beyond the capacities of their present hardware. With this in mind, Western analysts, many with overactive imaginations, have spent over a decade watching for the next generation of Soviet spacecraft.

Albatros

From the mid seventies to the early eighties, there

were a flurry of reports about Soviet development of a small spaceplane, called *Kosmoljot*, *Albatros*, or *Raketoplan*. The stories were in general agreement as to the vehicle's capabilities, (comparing it to the cancelled U.S. Air Force X-20 *Dynasoar*, a much smaller ship than the shuttle orbiter) and most of them predicted that the vehicle was in the final stages of development. Many said the new Soviet vehicle would beat the American shuttle into orbit, and that *Albatros* would use an advanced flyback booster and horizontal launch—both far beyond the abilities of the U.S. shuttle.

One of the key sources for these stories was Maarten Houtman, a European reporter. One story, based in large part on Houtman's articles, was published in the *Air University Review*, an official journal of the United States Air Force Academy. This story, and a classified companion article containing the same information, came to be cited in their own right as authoritative sources on the subject, proof that the Air Force knew *Albatros* was real. Clearly, the advanced capabilities ascribes to *Albatros* showed that the Soviets were about to leap ahead in space technology.

Unfortunately, according to Marcia Smith, "There are some indications . . . that what Maarten had come across were some design studies by students, and that they never were things that were intended to be brought to fruition. . . . He'd come across these and misinterpreted them. So," she says, "forget all about *Kosmoljot* and *Albatros*." *Albatros'* awesome technology seems to have been little more than Moscow Tech's Mechanical Drawing 101 class giving its students a chance to dream.

That should have been the end of it, but of course it wasn't. *Albatros* was not only a great story that played upon people's curiosity and fear, it was written up in the most sober and authoritative journals, and so gained credence. The *Air University Review* article was cited and reprinted as gospel, and other rumors arose to keep things interesting.

Cosmos by the Pair

New reports in the late seventies said that the Soviets were in the process of drop-testing their shuttle vehicle, or perhaps had already completed that phase. This news, apparently based on spy-satellite photos, came at just about the time that the U.S. shuttle was undergoing its own well-publicized drop tests. Nothing much else was heard of the Russian drop-tests, though they were cited in support of the imaginary *Albatros*. The Soviets certainly drop-tested *something* back then, an experimental aircraft or lifting body. Possibly the tests were geared toward shuttled development, and simply failed. Possibly they were part of a wholly unrelated project. They certainly weren't final tests of their current shuttle designs. Too much time has passed for the drops of the seventies to be directly linked to present work.

In another thread added to the tangle, a series of flights of paired mystery craft occurred in the late seventies. These were *Cosmos* 881/882, *Cosmos* 997/998 and *Cosmos* 1100/1101. (*Cosmos* is a sort of generic designation given by the Soviets to any space vehicle they don't wish to identify.) In each of these tests, a pair of very large payloads was boosted up and then returned back to earth after one orbit (though one of the 1100/1101 craft stayed up for two orbits). These *Cosmos* pairs seemed to perform gliding reentries, and there was a great deal of speculation that they were tests of a glide-back booster system. Nothing more was heard of the test series, but the mystery pairs kept Western analysts intrigued. Again, by now, these tests are too old to be linked to current research.

According to James Oberg, before these *Cosmos* pairs, the Soviets were confidently predicting the development of their own shuttle, and it was only *after* these tests that they started firmly insisting that they were *not* interested in a shuttle, and never had been. It's easy to infer that something went wrong with the tests and stopped the Russian shuttle effort cold.

Perhaps the whole idea of a Soviet shuttle would

have faded away when there weren't any follow-ups to these strange goings-on, but, just in time to prevent *Albatros* from getting a decent burial, a new mystery cropped up, one that took over where *Albatros* left off.

A Spaceplane?

Between June of 1982 and December of 1984, the Soviets staged four unusual orbital test flights: *Cosmos* 1374, *Cosmos* 1445, *Cosmos* 1517, and *Cosmos* 1614. Each of these four flights flew one orbit around the Earth, re-entered, glided toward its landing point, unfurled a parachute and then splashed down at sea—the first two in the Indian Ocean and the second two in the Black Sea—to be recovered by waiting Soviet ships. The Royal Australian Air Force flew reconnaissance planes close enough to the Indian Ocean splashdowns to get some very clear photos.

What the Soviets can be seen fishing out of the water in those shots is a space-going glider, obviously unmanned and far too small to carry a crew.

These glider missions didn't make any sense at all. Why would the Soviets land a glider in the ocean when all their manned missions—and virtually all their unmanned re-entry vehicles—have been landed within the vast confines of the Soviet Union? Even if the Soviets had little confidence in their ability to affect a pinpoint landing, why aim for water when Siberia is big enough to be hard to miss?

Assuming the gliders were testbeds for a re-flyable ship, why subject the heat shields, still blazing hot from the re-entry, to the severe thermal shock of water landing? Why further subject that shield to the highly corrosive effects of salt water? Surely damage from the water landing would impede studies of the shield.

For that matter, why risk losing the gliders altogether with ocean landings? A glider might sink—or a non-Soviet ship might perform an unsanctioned recovery. Why would the secretive Russians take (and lose) the gamble of western eyes seeing such a sensitive and important vehicle when the landings could have been

hidden deep among the steppes of Asia? It might be argued that the gliders *had* to be dropped in water so as to cushion a hard fall, but the Soviets have vast experience at land recovery, and a softer landing is simple to achieve—just put in a bigger parachute.

Why go to the expense and trouble of lofting the gliders into orbit when it would have been easier and cheaper to put them into suborbital path that would have allowed the same entry-and-glide tests?

To this day, no one has figured those gliders out completely. In an irony typical of Soviet space program analysis, the vehicle for which the clearest photographs and best details are available is one of the least understood parts of their shuttle development program—if it is indeed part of that program at all. But what else could it be?

Perhaps, instead of being a testbed for a shuttle comparable to the U.S. vehicle, it is a scale model of a spaceplane similar to the old USAF *Dynasoar* plans. But, while a *Dynasoar*-class ship would be somewhat more capable than the *Soyuz*, such a vehicle would represent a very extensive development cost for a marginal increase in capabilities. It has also been suggested that the glider is going to turn out to be a space fighter. This is the position taken by the United States Defense Department. The 1985 edition of the Defense Department publication *Soviet Military Power* featured a fanciful painting of a manned, scaled-up version of the glider, shown in orbit, shooting down a satellite in a manner more in keeping with World War I fighters than with realistic concepts of space attack.

Somewhat less whimsical illustrations and text in the Defense Department publication and elsewhere assume that the gliders are the forerunners of a military spaceplane. Numerous highly detailed and official looking drawings have shown the spaceplanes perched atop booster rockets. The trouble is, the spaceplane might not be as real as it looks in those views. Off the record, the artist of one of those authoritative-looking drawings grudgingly conceded that it was purely conjectural.

There's a variation on the space fighter idea—the suggestion that the glider might be a trans-atmospheric vehicle, or TAV, designed to operate above the sensible atmosphere but generally below orbital velocity. Marcia Smith, though unconvinced, conceded that the gliders look “a lot like a trans-atmospheric vehicle.” But there are problems with the spacefighter/TAV theory, related to its booster, which we'll come back to.

James Oberg, a noted expert on the Soviet space program, has put forward the idea that the gliders were not scale models at all. He suggests they might be full-size final-development-phase test vehicles of gliding-reentry Fractional Orbit Bombardment System (FOBS), a nuclear-armed gliding warhead meant to be launched into a partial orbit and then dropped for a controlled landing. Such a weapon would be sent against a large, moving target that would be difficult for a conventional ICBM to hit. Oberg makes a pretty fair case for the FOBS idea, based on analyses of orbital parameters, launch sites, and other factors. One intriguing datum that supports his theory has come to light recently: NASA studies of the gliders suggest that they might have used an ablative, non-reusable heatshield. That would make no sense in a reusable spacecraft or TAV, but a gliding bomb would only use its heatshield once before it blew up over its target.

But do the Soviets need such an elaborate weapon, which would require lengthy and expensive development? What would they aim it at? The only obvious large moving targets are U.S. aircraft carrier battle groups. But from bombers to submarine-launched cruise missiles, the Soviets already have extensive means for attacking the flattops—and are there enough carriers out there to merit the creation of such a specialized weapon?

New Boosters

At the same time the space glider puzzle was heating up, new work was proceeding on far larger—and technically more challenging—spacecraft at Tyuratam, the

Central Asian spaceport for Soviet manned missions. By the early 1980s, U.S. spy satellites were snapping photos of enormous construction taking place there. In the words of Stuart Koehl of Applied Technology Associates, you'd have to "take the work done to build up Kennedy Space Center in the Apollo era—and then double it" to even approach the intense level of activity at Tyuratam.

More than buildings were going up: two large new boosters were being put together. Like all Soviet boosters, the smaller of the two has been variously named in the West, in this case as the Medium Lift Launch Vehicle (MLLV) and as the SL-X-16 or SL-16. The MLLV is supposed to be able to put about 33,000 pounds (15,000 kilograms) into orbit, with a liftoff thrust of about 1,300,000 pounds (600,000 kilograms). The impressive drawings of the alleged spaceplane have it stuck atop the MLLV. The second and larger booster is the Heavy Lift Launch Vehicle (HLLV)—and it's heavy, all right, with a liftoff thrust estimated at about 6.6 million pounds (3 million kilograms). It is expected that it will be able to lift about 220,000 pounds (100,000 kilograms) into low earth orbit, although some earlier estimates had that figure 50 percent higher.

The HLLV consists of a huge core vehicle using a variant of the Medium Lift Launch Vehicle as a strap-on. (Apparently because the U.S. shuttle uses an External Tank, the Soviet core vehicle is often referred to as an ET. It isn't. It's a full-fledged booster that sports its own engines.) The strap-ons would be jettisoned after their fuel was exhausted. The U.S. shuttle drops its two solid-rocket boosters in much the same way. Presumably, the MLLV and HLLV will use a common engine type—why develop two engines instead of one? U.S. analysts expect the core to have four MLLV strap-ons.

The Heavy Lift Launch Vehicle is expected to lift a Soviet vehicle remarkably like a U.S. space shuttle orbiter into space. That orbiter will ride the side of the core vehicle, just as the U.S. orbiter rides the side of its

ET. The HLLV can also fly with a big cargo pod riding alongside instead of the orbiter.

Their Orbiter

The Soviet orbiter (often referred to as the heavy shuttle to distinguish it from the spaceplane) is just about the same shape as the U.S. orbiter, but slightly smaller. The U.S. vehicle is 122 feet (37 meters) long, while the Soviet version is about 109 feet (33 meters) long. The U.S. craft has a 78-foot (24 meter) wingspan, while the Soviet wings have a 76-foot (23 meter) span. The key difference between the two ships is that the Soviet orbiter does not have its own booster engines, as the American shuttle does. Presumably, the Soviet orbiter does have smaller engines for orbital maneuvering.

A few observers have noted the outward similarity of the two birds and suggested that the Soviet orbiter is a direct steal of the U.S. vehicle. But the severe and widely varying aerodynamic environments a big gliding spacecraft must encounter more or less require a vehicle shaped much like the Soviet or American craft. "It's a nitwit idea that their shuttle is a copy of ours," Oberg says flatly. The absence of engines means the aft of the Soviet orbiter can be and has been designed as a streamlined boat-tail, a far more aerodynamic shape than the American vehicle. Without engines, the center of gravity will be entirely different, the structural support system must be other than on the American ship, and so forth. It is also possible, says Oberg, that the Soviet bird will have an aft hatch built into its boat tail, instead of the clamshell payload bay doors that run the length of the *Columbia* and her sisters. An aft payload hatch would mean a far simpler and lighter structure. However, some of the satellite images are reputed to show payload bay doors similar to those on the American orbiters.

There's an element of circular reasoning in the reports that the Soviet craft is a clone of the American bird. People point to the official Pentagon drawings of the Soviet vehicle as proof that it's just like ours—but the official drawings by the Pentagon almost certainly

are drawings of the American bird, except with CCCP written on it instead of USA. An illustration in the 1986 edition of the Pentagon's *Soviet Military Power* shows a "Soviet" orbiter virtually identical to the American craft—down to having an American style boxy, unstreamlined tail section obviously intended to accommodate engines—but there are no engines in it. (There's even a U.S.-style rear body flap to shield the nonexistent engines from aerodynamic stress.)

It is unlikely that the U.S. Air Force actually thinks that's what the Soviet craft looks like—after all, they've taken enough pictures of the thing. The Pentagon illustrations are a gentle bit of disinformation, providing the public with a picture of the Soviet effort without letting the Soviets know how much we know. Result: analysts who point to a doctored-up drawing of the *American* shuttle as proof that the Soviet shuttle is a copy of ours!

It of course must be assumed that the Soviets carefully examined the vast amounts of data on the U.S. shuttle that is publicly available, and saved some work by learning from the U.S. experience. Undoubtedly they are also very interested in nonpublic data about the U.S. system. As Stuart Koehl puts it, "They steal nothing but the best technology." Oberg confirms that the American thermal protection system—the shuttle heatshield—is on the top of the list of technologies the Russians are trying to get their hands on. But even with all that, the differences between the American and Russian craft make it clear that the Russian orbiter is its own bird.

If that seems confused, things used to be worse.

Either because no one knew or because they weren't saying, earlier Pentagon reports altogether dodged the fact that the Soviet orbiter has no main engines. Previous U.S. Defense Department illustrations of it were from angles that hid the tail section, or showed the boosters in such a way that it was impossible to tell if the engines were on the booster or the orbiter.

A recent development suggests the Soviet shuttle might be significantly delayed. *Aviation Week and Space Technology* reports that the Soviets are adding jet engines to

their orbiter prototypes. The engines would be used when an orbiter was in the atmosphere, gliding back to Earth after a mission. The AW&ST report seems to imply that the jet engines were a late add to the craft, and not a part of the original orbiter design. If the reports are accurate, the Soviets have handed themselves a major headache. Introducing such a major system at this late date would inevitably slow things to a crawl, as a whole new set of complex components—fuel pumps, turbines, air scoops, throttles, and so on—have to be integrated into a ship that was not designed to carry them. But we just don't know what the facts are. Maybe the jets were always meant to be there—or maybe they aren't there now, and never will be.

Propulsion Questions

The Russian orbiter's lack of on-board engines means that it will be a hitch-hiker into space, riding the side of the expendable HLLV booster. The HLLV and MLLV require a bit more consideration at this point. Most observers of the Soviet program expect that the new boosters will use the most energetic liquid propellants, super-cooled (or cryogenic) liquid hydrogen and liquid oxygen. (The reusable U.S. Space Shuttle Main Engines (SSME) use this dual-cryogenic combination). There is good hard evidence that the Soviets will go cryo: large cryogenic storage tanks of the sort needed to hold these fuels have been sighted at Tyuratam, and vapors consistent with boil-off from those tanks have been detected. "It makes a lot of sense for them to finally transition to the dual-cryogenic fuels," Marcia Smith says.

James Oberg is not as convinced. "Liquid hydrogen is a tough technology," he points out. Hydrogen must be cooled to -252.7 degrees Celsius (-423 degrees Fahrenheit) to condense into a liquid, and working with such temperatures presents serious technical challenges in the fields of insulation, thermal-stress control and fluid handling. "It took us a long time" to learn how to work with it, Oberg says. "We did it in a very step by step entré to that area." U.S. mastery of the dual-

cryogenic propellants went through the unmanned Centaur upper stage through a number of partially cryogenic stages and fully cryogenic stages on manned vehicles before attempting the reusable, high-power—and still cantankerous—SSME. Soviet experience with supercooled fluid propellants at best had been limited. Some observers think it has been close to non-existent. "To go from a standing start to a shuttle main engine—we couldn't have done it," Oberg says. It is therefore arguable that the Soviets will stick with less challenging—and less powerful—propellants, unless they are willing to deal with some major development headaches.

The Soviets might face another problem in using cryogenic propellant. If the vehicles used in the four *Cosmos* glider flights discussed above are in fact military craft, the liquid oxygen/liquid hydrogen combination would be most unsuitable. Most of the missions envisioned for a space fighter or trans-atmospheric vehicle require a quick response—the ability to pop up into orbit quickly and perform an urgent reconnaissance job during a crisis, for example. Obviously, this would require a spaceplane's booster to be always at the ready. But supercooled fluids put a lot of thermal stress on a booster's tankage and other structures, and therefore cryogenic stages generally can't be kept tanked up at all times without damaging the rocket. It takes time, perhaps hours or days, to prepare a cryogenic rocket for flight—a drawback for a TAV's quick-response missions.

Apparently, none of the new Soviet boosters are intended for re-use, which would seem to be more of a minus than it really is. NASA's problems with high operating costs and turning its orbiters around between flights demonstrates that re-usability is not necessarily the key to economic space operation. Old-fashioned expendable launch vehicles are finding their way back into the U.S. stable of launchers. But Smith is still ready to see the Soviets use boosters that aren't thrown away. "They either are going to have to recover [the HLLV] or else they're going to have plan not to launch it very often, because one could assume that they don't

have much of a production base built up to build these [cryogenic] engines," she says. But there's a practical difficulty, involved in recovering the core booster. After burning up its fuel, it will probably be moving too fast and be much too far down range to be recovered.

So what do we know? We can use measurements derived from satellite photos to calculate the internal volumes of the booster. From there it is a straightforward job to figure out how much propellant it could carry. But satellite photos have their limits. We don't know for sure how many engines each of these booster rockets have. Charles Vick has performed some careful calculations based on the volume and diameters of the vehicles, and the physical requirements of rocket engines. He concludes that the MLLV, and the strap-on based on the MLLV, have two engines each, and that the core vehicle of the HLLV has four similar engines. But we're not certain which propellants these crafts will use, how powerful each of these engines will be, or how long they are expected to burn. We don't know how much the boosters themselves weigh. A precise calculation of booster performance is impossible without this information.

Typos and Bison

Aside from its fanciful pictures, the Pentagon has been misleading on the subject of the Soviet orbiter on at least one other occasion, although this seems more in the nature of a typo than a fib. Like many typos, it has been enshrined as a True Fact. The Russian heavy lift shuttle made its debut in the 1983 edition of *Soviet Military Power*, where it was credited with a payload capacity of 60,000 kilograms, about twice the muscle of the U.S. vehicle. The 60,000 kilogram figure was then prominently quoted in many articles about the Soviet program.

Later Pentagon reports quietly scaled the Soviet vehicle's lifting ability down to 30,000 kilograms payload. Now, 30,000 kilograms works out to 65,000 pounds, the U.S. orbiter payload capacity. This coincidence is rather suggestive. Perhaps a Pentagon analyst, knowing very little about the Soviet orbiter, and needing numbers on

it, simply assigned it a payload capability of 60,000 pounds—a bit less than that of the American craft, on the logic that the Soviet ship looked the same but was slightly smaller. Then someone in the editorial department got mixed up converting pounds to kilograms, and the abilities of the Soviet vehicle were magically doubled.

Incidentally, the U.S. orbiter has never lofted more than 48,000 pounds (22,000 kilograms), so that estimate of Soviet payload capacity might be based on a hypothetical U.S. capacity that is yet to be reached. As it hasn't yet reached its own specs, we don't know, exactly, the abilities of the U.S. shuttle. Even if we knew a lot more about the Soviet orbiter, (how it's built, how heavy it is, etc.) it would be impossible to get an exact figure on how much it could carry. With so many unknowns, any payload figures must be taken with a large grain of salt. Current estimates put the figure at about the same as the official capacity of the U.S. shuttle, or slightly lower.

There is at least one more big mystery surrounding the Soviet shuttle. Two orbiters have been photographed at their base near Moscow, and the orbiter has many times been seen set atop a modified Myasishchev-4 Bison bomber. It's easy to assume that it's on the Bison for purposes of being drop-tested, just as the U.S. shuttle was tested by being dropped off a Boeing 747. The further obvious conclusion is that the Bison will be used to transport the orbiter, just as the 747 is used to move American orbiters from one place to another.

But the Bison, a rather elderly aircraft, is much smaller than a 747, and has a maximum take-off weight (aircraft, fuel, and payload combined) of 165,000 kilograms (363,760 pounds)—about half the figure for the 747. According to *Jane's All The World's Aircraft 1984-85*, a specially modified Bison, presumably stripped of all nonessential gear for the purposes of setting a payload record, managed in 1959 to haul 55,220 kilograms (121,480 pounds) to 2000-meters (6560 feet). When flying as a bomber the Bison is rated for a payload of 5,450 kilograms (12,000 pounds).

The U.S. orbiter weighs about 68,000 kilograms (150,000 pounds). The Soviet orbiter probably weighs

in close to that—and it is almost certainly heavier than the greatest weight a Bison has ever hauled into the air. Worse still, the orbiter rides *atop* the Bison. This would create huge drag problems and degrade the Bison's payload capacity. External and internal bracing and other needed modifications (like beefed-up landing gear and increased vertical stabilizer areas) would add more weight and cut more deeply into the usable payload. The Bison that hauled the 55,220 kilograms must have itself been a lower-weight and more nimble bird than the airplane modified to haul the orbiters. There's one more piece to the equation: the distance between the Moscow airbase where the orbiters are, to the Tyuratam spacebase where they have to go, is just about 1,600 kilometers (1,000 miles). The heavy fuel load required to cross that distance would also cut into the payload. Mid-air refueling could help, but the flight would certainly be difficult.

It is just about conceivable that the Bison has been extensively upgraded and that the Soviet orbiters are a lot lighter than expected. But even giving the Bison/orbiter combination every imaginable break, at best the Soviets are left with a dangerously overloaded vehicle that might just about claw itself into the air at great risk. Even that seems unlikely. An obvious explanation to the puzzle is that the orbiter seen atop the Bison isn't an orbiter at all, but merely a hollow shell, an orbiter-shaped boilerplate mockup. Oberg believes this is what the spy satellites have been photographing. He doesn't think either of the Soviet orbiters seen so far are as capable as the *Enterprise*—and the *Enterprise*, built specifically for drop-tests and other R&D work, is incapable of spaceflight.

Even a boilerplate orbiter might be pretty heavy for a bomber with a normal payload of 5,450 kilograms. Some of the best U.S. photographs of the orbiter were taken when the Bison carrying it went off the runway and got stuck in the mud for two days—just the sort of thing that happens to overloaded airplanes.

Why build dummy orbiters and stick them atop a Bison bomber? Oberg suggests that the Soviets are using the Bison as a sort of flying wind tunnel to learn

more about the orbiter's aerodynamics. Or perhaps the Soviets are using a surplus Bison while they practice the difficult art of mounting one large flying vehicle on another. Then, once they have the procedure under control, they could move to a more modern transport that could lift a real orbiter.

A more paranoid theory claims that the Soviet orbiter program is a fake, and the dummy orbiters have been built for the sole purpose of being photographed by U.S. Air Force satellites. One source for this article (which directly contradicts all others) flatly states that the Bison/orbiter has never flown at all, thus supporting the deception theory. But going to that much effort seems like unnecessarily sneaky behavior, even for the Soviets. It's simply hard to think of a believable motive for such an elaborate stunt. Why advertise a fake spacecraft that might scare the Americans into increased funding for their own program? The orbiter must be real. The Soviets simply haven't built a flyable craft yet.

When Will They Fly?

As this is written, only the Medium Lift booster has flown, and that only in four suborbital tests. The heavy shuttle, the hypothetical spaceplane, and the Heavy Lift Launch Vehicle have never been launched. Presumably, before the spaceplane (if it exists) or the orbiter can be flown, the boosters that carry them must be proved. That proving program has just begun. (On the other hand, the U.S. shuttle flew on the first flight of its booster—and flew manned).

Craig Couvaut of *Aviation Week and Space Technology* believes that the four suborbital MLLV flights included only the lower stage. That suggests that the upper stage isn't ready yet but the MLLV strap-on variant (which would only use the MLLV lower stage) could be very close to ready. That in turn suggests that the HLLV might be flight-tested soon.

At this writing, the heavy lift booster has been stuck on the ground for over two years. There are unconfirmed reports of a successful static firing test, which would be an important development if true.

When will the orbit-capable MLLV and HLLV take off? No one knows, and perhaps no one in Russia knows either. Development of a booster is a chancy business. A flight could come tomorrow, or years from now. But the flight will happen.

The Guessing Game

Watching the Soviets requires a certain amount of tea-leaf reading. Great things must be extrapolated from tiny scraps of data, and some clues suggest that new spacecraft and big changes still might be a long way off.

In March 1986, the official Soviet news agency TASS threw everyone a curve with its cryptical announcement that the then-current manned mission, *Soyuz T-15* would be the last of its class to fly. Did that mean the new shuttle and/or spaceplane was ready to go? Was some new surprise in store? Anticlimatically, what next flew was a tweaked-up version of the same old *Soyuz*.

But if the Soviets were close on the spaceplane or the shuttle, why would they continue to improve a twenty-year-old design? Craig Couvaut suggests that the new *Soyuz* design could serve as a testbed for spaceplane and shuttle hardware, but again that seems like a lot of effort for modest gain.

Furthermore, designing *Salyut's* descendant *Mir* to be compatible with both *Soyuz* and the newer spacecraft would be more difficult than designing it to handle only one. It's not just a matter of putting the same docking ports on everything: there are questions of station-keeping thruster burns, dynamic loads, maintaining center of gravity, and structure stiffness—problems of thermal stresses related to what components shade what from the sun, electric power needs, and so on. Are you docking a 7,500 pound or 150,000 pound spacecraft to that space station? It makes a big difference. It is entirely possible that the spaceplane and/or the heavy shuttle will not be able to dock with *Mir*.

Mir and the new *Soyuz* are both rather conservative refinements of mature, even elderly systems. It seems strange that the Russians would continue developing

and improving them just to obscure the fact that they were about to unleash brand new systems. Reading the tea leaves *that way* in turn suggests that the new birds won't be flying anytime soon.

The spaceplane seems to be a far less challenging project, and one that would teach the Soviets a lot on the way to building their heavy shuttle. But while test articles of a full size Soviet orbiter have been around for years, no full scale spaceplane has ever been seen. In fact, the last indication of this program was the December 1984 *Cosmos* 1614 flight.

As for the heavy shuttle, it must represent a tremendous technical challenge for the Soviets. The computers, guidance and control systems, power systems, and thermal protection systems a space shuttle requires are far beyond anything they have ever tried to fly. It must in many ways seem a daunting prospect, something like America trying to go from *Gemini* to our own shuttle in one jump.

Taking Chances

As they create these new craft, the Soviets will take both more and fewer chances than do American space scientists. More risks in the sense that their spacecraft have historically had a higher failure rate than ours—more aborts, more accidents, more close calls. Fewer risks because they are very conservative engineers, unwilling to throw anything away if it works. They will stick with the tried-and-true techniques as much as possible, where an American engineer would be tempted to try a whole new approach. But their more old-fashioned hardware does fail frequently, and does not include as many back-ups or as big a margin of error as the U.S. vehicles. As Stuart Koehl put it, "They don't goldplate. They have a much narrower safety margin."

Still, the cosmonaut is a revered figure in the Soviet Union. The Russians tender him more respect and hero-worship than Americans afford the biggest sports hero or movie star. No Soviet technician wants to risk the life of a icon. There are many pressures beyond their

somewhat backward technology that push the Soviet space program into a conservative mode of operation.

In the wake of the sloppy work that led to the totally unnecessary *Challenger* disaster, Americans cannot afford to denigrate the competence of Soviet flight safety engineering. Both nations have lost crews in flight. But even with that said, a given piece of Soviet hardware will probably be of less advanced design than the American equivalent, it will not be as well made, or as carefully tested, nor will it be as likely to have some sort of back-up.

In spite of the enormous challenges faced by the Soviet shuttle project, some observers, (including those in the Pentagon) see a flight for the orbiter by late 1986 or 1987, but pessimists put it as far away as 1993. No one really knows if the spaceplane is real, so no one knows if or when it will fly.

Even once the new boosters and spacecraft have flown, the Soviets will not be in any position to conquer the universe, despite good sf stories to the contrary. The new birds will require a lengthy development period, and even when they are fully operational (something the U.S. shuttle isn't after nearly six years), they will produce mostly quantitative, rather than qualitative, changes in Soviet space operations.

Our shuttle revolutionized the way we do things in orbit, more than it changed *what* we do. It's a great ship, but it hasn't—and couldn't—conquer the universe for us. The Soviets have been flying space stations of one sort or another for over a decade without ending Western civilization as we know it. If they fly a bigger station, or travel to it in a new craft, it won't make *that* much difference to us. If it ever flies, the spaceplane will not turn the whole world upside down, though it will afford new flexibility and sophistication to Soviet space operations.

In the huge new facilities of Tyuratam, some very good minds are working on engineering jobs that must either daunt or spark the imagination of all those around the big new birds. As Craig Couvaut of *Aviation Week and Space Technology* has said, "it must be exciting to be a young Russian space engineer."

YOUNG AS YOU FEEL

In an earlier edition of Far Frontiers I opined that while freedom is the inalienable right of the adult, license is the all-too-often-granted privilege of the incontinent. But how do you define an adult? Roger Allen provides one answer. . . .

—JPB

YOUNG AS YOU FEEL

Roger MacBride Allen

As Elbert watched, little Emily picked up the bowl of oatmeal and dumped it on her head. Her (slightly) older brother George was in the next room, drawing on the wall (again) because he had run out of paper (again). The two kittens, Disaster and Mayhem, rocketed into the kitchen, chasing each other. The two balls of fur leapt from the floor to Elbert's lap to the inverted bowl of oatmeal on Emily's head, back down to the floor, and then vanished out the hall door. Emily crowed with delight, forgot what was funny, noticed her spoon, used it to scoop up a blob of oatmeal from the highchair tray, and politely offered the spoonful to Uncle Elbert.

Just as politely, twenty-one-year-old Elbert declined the offer. Babysitting for his brother Sam's kids always got him a little rattled, and today was no different. It wasn't the noise or the mess or the feeling of everything happening at once all the time that got to him. It was the way nothing made *sense*. He was as nuts about his niece and nephew as any uncle could be, but he wished he could *understand* them. What turned a bowl of cereal into a hat, or new wallpaper into a broad canvas?

Elbert peeled the bowl off Emily's eighteen-month-old head, wiped off the worst of the glop, and went into

the living room to yell at George for the twentieth time about crayons on walls.

How could George possibly think he could get away with drawing on walls *this* time, after being yelled at the last nineteen times? He was a bright almost-four-year-old, surely he could understand if he wanted to. "George, cut it out, all right?"

"Why?"

"Because it makes the walls ugly."

"I think it looks better than those dumb flowers!"

Elbert looked over the busy, almost lurid floral design, and had to admit to himself George had a point. "Well, your mom doesn't think so. We'd better play by her rules."

"Why?"

"Because." Elbert put just enough force behind the word to make sure it was an end to the discussion and not the beginning of another endless "why-because-why" cycle. "Just stick to your coloring books from now on." He went back to the kitchen to dig up the spray cleaner, and arrived to discover that Emily had just figured out how to escape from her highchair. Moving quickly, he followed the trail of oatmeal down the hall to the kid's bedroom, and found Emily standing on slightly wobbly feet, tugging at an electric cord for no apparent reason. Elbert saw what was about to happen, rushed in, and grabbed the falling Winnie-the-Pooh lamp out of midair. Emily clapped her hands, over-balanced, and accidentally sat down. This brought her attention to her shoes and socks. She started peeling them off. Elbert sighed, sat down on the floor, and started putting them back on. Emily would peel off the left while he was working on the right, and then switch to the right while Elbert was lacing up the left. It took four complete cycles before he caught up with her and she lost interest in the game. Meanwhile, George had wandered into the room and started trying to build a fort out of his blocks and then put the kittens in it, but the two little furballs weren't cooperating. It was a long afternoon for a babysitting uncle.

Elbert was very glad to see his brother Sam when he came in, and made his escape with slightly more dispatch than usual. Elbert had had enough of keeping the kittens off the drapes and the kids off the kittens. Sam watched Elbert roar off in that crazy car of his, and shook his head, worrying his habitual brotherly worries. Elbert, Sam thought, was a grown-up genius in so many ways, still just a silly kid in so many others.

In Sam's eyes, Elbert was living proof that it wasn't always smart to finish first. Elbert had shot through the Boston public schools in near-record time, skipping as many grades as he actually attended. Elbert was in Harvard on a scholarship by age 15, and had completed all his undergrad work there by the time he was 18. He had majored in biology, and vanished into grad school in biochemistry two days after graduation. By the time he was 20, he was an assistant professor in biochemistry, and was younger than most of the people in the classes he taught. That interesting statistic had pushed him out of the classroom, which left him no place to go but into research—and the higher-ups in the department were just as happy to see Elbert shunted out of teaching. He made the students nervous. That was what bothered Sam. It *had* to be a lonely existence for Elbert, in a lot of ways.

Sam was a pretty smart guy himself, and a noted biochemist in his own right. Big brother Sam's chosen field had certainly influenced Elbert's career decision. But Sam had tired of academia and moved out into the real-life grown-up world. He was working for the Drug Enforcement Agency now, tracking the designer drug manufacturing sleazeballs, working in his lab, trying to stay a step ahead of the creeps who preyed on the junkies. It was a rough game, serious, useful work and Sam looked like a man who wanted real work—big, burly, with a thick handlebar moustache, dark hair, and thick brows framing a serious, almost grim face. He was twice the size of his kid brother.

Sam worried that Elbert wasn't interested in "real" work. Suppose Elbert ended up hiding from the world

inside the fortress of academia for the rest of his life? Sam turned from the window, scooped up little Emily, called to George, and went to the bookshelf. It was story time for the kids.

As he hacked and cursed his way through Cambridge traffic, Elbert didn't feel very insulated from real-life problems. Academia was handing him plenty of aggravation. But fighting through the other drivers at least let him blow off a little steam. It wasn't until he pulled his souped-up '56 Mercury up in front of his fire-trap apartment behind Central Square that he managed to sit still long enough to think about his own situation.

Elbert was a nice enough guy, but it was perhaps inevitable that anyone who moved that fast through school, leaving his age-peers far behind, never being old enough or settled enough to be part of a group, would develop a few protective twitches. If he had developed the *standard* twitches, things might have been all right. Harvard understood the concept of genius-as-nerd, but Elbert didn't fit that picture as well as he might. Elbert's appearance was perhaps too much a mix of the cliché and the odd to do him any good.

He was a pale, almost sallow-complexioned young man, with translucent, baby-smooth skin that had yet to know a razor, his black hair and heavy eyebrows accentuating his wraith-like coloration. He was short and slightly built, with delicate long-fingered hands, as if in the rush to grow his mind, Nature had been forced to let his body fall behind.

If he had worn coke-bottle-thick hornrims, white button-down polycotton shirts, and highwater pants, if he had been a recluse suffering from terminal shyness, Harvard people might have understood him. But Elbert was a pretty snappy dresser, more likely to wear a Hawaiian print shirt (though with a shirtpocket protector filled with pens and gizmos) and khaki pants. Instead of Oxfords, he wore camouflage-pattern hi-top sneakers. With contact lenses instead of glasses, it was hard to miss the twinkle in his eyes. He was a warm-hearted, gregarious sort, though he tended to hang out

with undergrads—and not only undergrads, but *freshmen*, for God's sake. For a Harvard grad student, that was a fatal *faux pas* right there. But Elbert threw a mean frisbee, even if he was too frail for the rougher games of touch football in the quad.

On top of everything else, he was as likely to be tinkering with his fire-engine-red '56 Merc as with his test tubes, and no one on campus knew how to respond to a grease monkey.

The long and the short of it was, he didn't fit any of the molds Harvard had in stock. None of the standard-issue solutions to the problem of a slightly screwy genius seemed to fit, because he wasn't your standard-issue screwball.

Harvard didn't know what to do with him. But, at just the right moment in the worrying about Elbert, another researcher quit to take a job in that half-mythical never-never land, the Private Sector, and they needed someone to take up the job. So Elbert was stuck in a tiny basement office, given lab access, and handed a \$10,000 National Science Foundation grant to study some niggling little question regarding one of the best studied parts of the human body, the thyroid gland. And that should have been the end of that. The hand-me-down job was expected to take him months, maybe the entire school year, and by then, it was hoped, something else might present itself.

Unfortunately, Elbert had gotten the study done, by himself, ahead of time and under budget. He never used the assistant he had been budgeted for, or even touched the travel money he had been expected to use. At the end, he still had nearly eight grand of the grant left in the bank.

He had done a good job fast, but in an interesting bit of applied psychology that Elbert wished someone would study someday, there would even be a tendency to discount his results because he was under budget. He had found a few things out about the thyroid—minor points, but sure to cause some contention in the insular world of the glandular-studies racket. The scientists

who felt their work challenged by his finding would have a very effective—and very unfair—defense: Who could believe numbers that only cost two grand to produce? It must be sloppy work, and besides, it's just that weird grad student at Harvard. Elbert was young, at the start of his career. He couldn't afford a rep for being disbelieved. It was good science but bad politics for him to prove the old guard had blown it on the thyroid. Elbert needed some protective coloration.

He sighed and dug a beer out of the apartment's rusting old Frigidaire. He was faced with one of the worst quandaries possible in the game of grantsmanship, a game he had been forced to learn as quickly as everything else about being a modern scientist.

If Elbert couldn't spend the surplus eight grand in some legitimate scientific fashion, in some study that had at least some vague connection with the original purpose of the grant, he would have to return the money. If he did *that*, it would be that much harder for him to raise money in the future. The grant-givers would suspect him of sloppy accounting—which wouldn't really be fair, since he hadn't had a thing to do with the original grant proposal. But the grant was his *now*, so the blame would be his.

But worst of all, the surplus money was sitting in the Central Cooperative Bank, gathering an untoward amount of interest. Elbert had unwisely shopped around and picked out a fast-moving money market account. He had to get rid of that money, quickly, and at least semi-legitimately.

Elbert opened the flip-top on the brew, and took the fire escape up to the tar-papered roof of the two-story building. From here he had a terrific view of all the other tarpaper roofs for blocks around, but at least there was a breath of air. He liked to do his thinking up here, in a mouldering old deck chair.

There was still a blob of oatmeal stuck to his shirt. He scraped it off and found himself wondering again about what on earth Emily had thought she was doing.

Elbert knew he couldn't be the first person to won-

der what went on in the mind of a child, but it was slowly dawning on him that he might be the first person to be in a position to find out.

He took a sip of beer and sat down on the rusty lawn chair. Hold it a second. Maybe this was the sort of project that could suck up that leftover money.

Okay. Emily, George, every perfectly normal little kid, seemed to live in his or her own little world. And you could throw in kittens and practically every other baby mammal. It was so accepted that baby animals behaved differently from adults that no one had ever thought to consider the *mechanism* that caused that different behavior. People had studied the development of human behavior from infant to adult until they were blue in the face—but had anyone ever looked under the hood, so to speak, to see what was *causing* those shifts in behavior? How did it happen?

A baby's brain was pretty much the same as an adult's. There wasn't any new bit of the brain, no new structure, that grew up when a kid turned into an adult. Logically, that meant something happened to the brain's operation as a person grew up. And, to a young scientist who had been bogged down with the thyroid for too long, that suggested a hormonal function.

And then some little synapse in his own brain fired, and he thought of the theories about neoteny in human evolution.

He suddenly knew how to spend that money. He had an idea, a really *stupid* one, a theory that couldn't possibly be right. Testing it could soak up that cash and let him turn in a bland, "hypothesis disproved" paper that wouldn't bother anyone and would allow him to look conventional because he was confirming the mainstream, the obvious.

Bad science, but a great career move. Elbert was learning fast.

The travel money vanished into plane fare to Atlanta, and a motel room in a run-down joint near the Yerkes Primate Research Institute. Elbert was at Yerkes five

days, of which the first three were spent wheedling one office after another getting permissions. It was a cockamamie idea, and Elbert knew it, but Elbert Miller's rep as a Harvard boy wonder had preceded him, and they finally let him do it.

He drew a 50-cc blood sample from every adult and baby chimp in the place, and got bitten three times in the process. The blood-drawing took two days, and then he was jetting back to Cambridge on the red-eye express, dipping into the travel budget to buy a second ticket on the plane so he could carry the chilled and insulated cartons full of chimp blood on the seat next to him where he could keep an eye on them.

He shot the last ten travel bucks taking a cab from Logan Airport back to the lab, and actually paid for the tip out of his own pocket. It was well past midnight when he arrived at the lab, but the blood samples had to be stored properly at once or they'd start to decay. And so long as he was there, actually at the lab, it only made sense for him to get started on the preliminary work, get at least a few hours in on the project. . . .

He was still hard at it at 9 A.M. the next morning, when the building started to fill up. Elbert had known perfectly well that he would stay at it all night, but pretending he wouldn't was a part of the game he played with himself. And it didn't really matter—at age 21, he was still young enough to pull all-nighters and not feel it.

The first person Elbert knew who happened to stroll past the door of his lab was Cindy Hanks, a tall, thin, gawky nineteen-year-old not yet recovered from her latest bout with acne. He all but literally grabbed her and dragged her into the room, and so hired the lab assistant he was budgeted for. He put her to work, and there was plenty of it for both of them. She centrifuged the samples while he started setting up the chemical tests.

Elbert took a break at lunch to run off some flyers and post them around the school, offering \$10 to people

willing to donate 50 cc's of their own blood, and \$20 for 50 cc's of a baby's blood. Elbert felt a little ghoulish in asking for the blood of a child, but he told himself that it was All for Science, wouldn't do the children any harm, and besides, to a grad student with a family, twenty bucks was twenty bucks. He hoped that enough parents would tell themselves the same thing.

They did. There was a line out the door, and Elbert had twice the number of donors he had hoped for by five that evening. That was all to the good, but he still felt a little creepy about it.

Elbert was poking around in chimp and human blood plasma looking for a certain hypothetical something. According to his not-very-serious theory, he would find little or none of it in adult chimp plasma, slightly more of it in adult humans, more still in baby chimps, and the largest proportion by far in human babies.

He already had a good, serious-sounding name for it: Latency Limiting Hormone—LLH. He told himself that he didn't really expect to find it—the whole thing was a lark, a pipe dream, a money sponge.

But even as he tried to convince himself of that, he had a hunch that he was on to something, that LLH made sense. It fit in with neoteny.

Neoteny is a quick-and-dirty, low-budget, rush-job way for evolution to work its magic. It can be defined as the retention of an ancestral form's juvenile characteristics in the adult form of a descendant species. *Homo sapiens* are notoriously neotenic. The high, domed forehead of the human skull is a classic example of neoteny. In many ways, a human skull looks much more like a baby chimp's skull than it looks like an *adult* chimp's cranium. A chimp starts out at birth with a skull that is high and rounded like a human's but the skull flattens out and gradually slopes back as the individual matures.

The human brain has room to be much larger than a chimp's because, as the human cranium grows, it largely retains the rounded shape of the infant skull. The famed Taung Baby skull, the first australopithecine found, looks

more "human" than adults of its own species because of its infantile rounded skull.

Other features of human anatomy are almost certainly neotenous throwbacks to the immature forms of an ancestor—our sparse body hair and small, flattened faces for example. If, Elbert asked himself, the body—and the shape of the brain itself—could be neotenous, couldn't behavior, the mind itself, be a throwback to an immature ancestor?

There was even some anecdotal evidence to support the idea. It could easily be argued that no other species retains a sense of playfulness as long into adulthood as humans: All kittens have senses of humor, but few cats do. Adult chimps rarely display playful behavior. But from kite flying to wild New Year's Eve parties, from executive desktop toys and the National Football League to grown men with train sets, humans certainly did. Nevertheless, kids played around more than adults. Some playfulness faded away. But how did that *work*? How did the playfulness (along with other juvenile behaviors) diminish? What machinery did the work? It was one of those perfectly good questions, intriguing when it finally came up, that no one had ever thought to ask before.

Elbert, to use the metaphor he himself chose, was looking under the hood to get the answer—unless, as could be argued, he was just fooling around. After all, he was still just a kid. . . .

Elbert knew that Latency Limiting Hormone, if it existed at all, ought to be all but impossible to identify and isolate. All Elbert had to go on in his search for it was his theory about its relative proportion in the blood of adult and immature chimps and humans, and a vague hunch that its chemical structure ought to look something like one of the opiates. His equipment was good, but not great, and his hunches and guesses should have been no substitute for years of patient study.

Working with exquisite care—and demanding the same of his dragooned assistant Cindy—he centrifuged the

blood samples into fractions, ran them through successively finer filters, systematically eliminating every identifiable cell, molecule, chemical and cold virus. He was left with a few hundred test tubes, each containing a few cc's of mystery scum suspended in blood plasma. According to Elbert's theory, each vial contained, along with all the other uncharted chemistries of blood (of which there were a number surprising to a lay person) a small sample of his hypothetical Latency Limiting Hormone. Adults should have very little, and babies should have a lot of it.

Finding LLH, identifying it—assuming it was there in the first place—should have made looking for a needle in a haystack look easy. It would take incredible luck, incredible intuition, incredible skill to crack the problem.

Elbert nailed it in three days of virtually round-the-clock work. At least, he had *something* that was found in exactly the right proportions in the various blood samples, something that seemed to have the right sort of chemistry.

He celebrated the discovery with Cindy Hanks by treating her to the questionable pleasures of coffee and a sweet roll at the Mug & Muffin in Harvard square. The java was bad, and the bakery goods could have been used as weapons, but that didn't matter. Back in the refrigerator at the lab was a vial containing a few cubic centimeters of *something* laboriously extracted from the blood samples. A quick bite to eat, maybe a little sleep, and he would set to work analyzing it.

Elbert was so cranked up on enthusiasm and adrenalin that he planned to keep going all night, but Cindy Hanks was a burn-out, and besides, she didn't know exactly what it was all about. So Elbert had found some dreary little chemical in blood plasma. So what?

"Elbert," Cindy said, "I'm glad you're making progress and all that, but what's the big deal? I mean, what's so important about this latency stuff?"

"Huh?" Elbert stopped with a refilled mug of coffee-flavored battery acid halfway to his mouth. The ques-

tion brought him up short. It all seemed so *obvious* to him. "LLH is—my God, well, jeez, it's so many things! Right off the top, it demonstrates a mechanism for behavioral evolution. It will mean practically starting over in some studies of how the brain works, add a whole new dimension to the research."

"But what is it? How does it work?" Cindy asked.

Elbert sighed and dropped his sweet roll back onto the plate, where it landed with a heavy *clunk*. "Okay, put very simply, if my pie-in-the-sky theories are borne out, Latency Limiting Hormone is what makes a baby mammal—*any* baby mammal, not just humans and chimps—LLH is what makes a baby *act like a baby*."

"Huh?"

"Why is it that baby animals frolic and play and chase after nothing?"

"Come on, that's an easy one," Cindy said. "There are a million studies showing play is an important learning mechanism. Kittens chase leaves and their tails to practice catching mice."

"Right. But then the kitten grows up and turns into a stodgy old cat. He stops playing—or at least stops playing as much. His whole behavior pattern changes. Why?"

"Because he's maturing."

"He's acting older because he's maturing. Circular reasoning. We know a lot about the chemical processes that change a *body* as it matures. What's the mechanism for behavioral change? I think I've got it back at the lab: LLH. LLH suppresses the brain circuitry that makes older animals act mature. It *limits* that *latent* adulthood. As you grow up, your body stops pumping LLH, and the less LLH you've got in your body, the more your latent tendency toward mature behavior shows up. Which is why, if I'm right, grown-ups act grown up. Adult humans should retain more of LLH than chimps—or any other mammal, which is why we tend to act sillier than mature chimps. And human kids should be positively awash in it. LLH is in their little brains, affecting their minds. Come on, we've got to get back."

Cindy sat there as Elbert paid the check. She thought hard for a minute, and then looked rather impressed as they left and crossed the street. She suddenly understood it. That wouldn't have mattered so much, if she hadn't been dating Tim Goldman. And even that wouldn't have been all right, if she hadn't quoted the phrase "affecting their minds" to him.

Tim Goldman, and the small but dangerous number like him, were sort of a waste product of higher learning. All the great schools produced a very few Tims now and then, and none of the schools wanted to talk about them much. They were the alumni who did well without doing good. They seemed to absorb book learning, but somehow the wisdom and decency didn't take. Result: highly trained young people who were brilliant, talented, and every bit as fit for human society as something you'd scrape off the bottom of your shoe. Amoral and sneering at whatever good and great things their classmates would do in the world, they chose the fields where a good sharp criminal mind could turn a nice profit.

It used to be that the Tim Goldmans of the world grew up to become stock market manipulators, Mob lawyers, con artists, skilled counterfeiters, smugglers, bribable politicians. Nowadays, in the age of high-tech, while all those jobs were still around, there were suddenly many more career possibilities for the more technically minded villain—computer theft, technology diversion, fraudulent toxic-waste disposal.

And of course there was Tim Goldman's chosen profession: illicit drug manufacturing.

Goldman called it consulting chemistry, and claimed to do a lot of analytical work for area research companies, even though few research company scientists have shoulder-length hair, wear sunglasses at three A.M. or call to pick up bags of white powder at that hour.

He kept Cindy away from his place and his work, but even so there were enough clues so that his chosen profession should have been hard to miss. Cindy managed not to see what should have been obvious. Either

she simply pretended not to know what Tim did, or she was honestly foolish enough to miss all the clues. Whatever the reason, she inexplicably played dumb. A better mystery was what she was doing hanging around Goldman in the first place, but then plenty of good women hang around with knuckle-draggers they know are no damn good.

Goldman had been "encouraged" to leave MIT a few years before when certain chemicals, useful in processing cocaine, turned up missing. Nothing could be proved and he still hung around Cambridge and Boston, pursuing his venal craft. He had met Cindy a few months before when he crashed a party, and he was spending most of his nights over at her place now.

So he heard about LLH from Cindy later that same night, twelve short hours after she had given up trying to gnaw on her petrified coffee shop muffin. Pillow talk.

"Timmy, it's just such an incredible idea!" Cindy burred. "I mean, this could really be what makes us tick! Retaining this LLH stuff in our adult brain chemistry explains a hell of a lot of human behavior!"

Goldman scratched his hairy chest and then tugged at his shaggy beard. "Yeah, I begin to see the possibilities." A lot of possibilities. He switched out the light and grinned broadly in the darkness.

Elbert found himself with two surprises the next day. The first was that he suddenly had an enthusiastic and talented new assistant, a real nice guy who was willing to work free. Cindy's boyfriend Tim was very excited about Latency Limiting Hormone, and was eager to help explore the possibilities.

The second surprise was that, somehow, suddenly the job at hand was trying to synthesize LLH. Elbert couldn't put his finger on how that goal was chosen, but there it was—and it even made sense. After all, the stuff was hard to come by naturally. If they were going to learn about it, it'd make sense to manufacture their own. That would be easier and cheaper all around.

It did seem like putting the cart before the horse, but

in the long run, how much would that matter? The work was getting done.

Elbert decided he liked this new guy Tim. He was smart, he was quick, he was eager, and he was skilled. Usually Elbert didn't get along with people older than he was, and Tim was easily over thirty. But Tim was *nice* to Elbert, and didn't try to boss him. Tim didn't assume he was smarter than Elbert because he was older. It was fun to be around Tim. And, like everyone else on the planet, Elbert worked better when he was happy.

Which, of course, suited Tim Goldman fine.

Elbert worked night and day at the problem, without ever knowing exactly why he was doing it. The whole urgent rush of it seemed crazy at times, even to him. For some strange reason, they didn't stop to test the effects of LLH: Tim roped them into an immediate analysis of the chemical structure of the straw-colored liquid Elbert had extracted from his victims. It *was* similar to the natural opiates, it turned out—and the opiates were a branch of biochem about which Tim Goldman knew a great deal. But why didn't they test its effects, Elbert wondered. It wasn't science.

That didn't worry Goldman. He was interested in a gamble, not science. If, *if* what Elbert had come up with in the straw-colored liquid of his did indeed inhibit adult behavior, then Goldman had lucked into the biggest designer-drug bonanza in history. If the glop they were calling LLH wasn't anything, he'd be mad, really mad. He could beat up Elbert to relieve his feelings. But if it were the real thing—visions of psychotropic sugarplums and hallucinogenic dollar signs danced before his eyes. He got Elbert to work all the harder.

Elbert gave up going home to his apartment to sleep. He set up a cot in the lab, and didn't get to use it much. It got so the thrill of the chase, rather than the goal itself, became important.

Two weeks later they had it—a cheap, simple way to crank out Latency Limiting Hormone in massive quanti-

ties. The day after that, Tim Goldman vanished, taking photocopies of all the paperwork and formulae with him. Luckily for Elbert's lifespan, Goldman decided it wasn't worth the bother to rub out this golden goose once the eggs were laid. Goldman didn't even destroy all the other copies of the notes, as he doubted Elbert would be likely to become a competitor before his real competitors had reverse-engineered LLH.

Elbert scarcely noticed that Goldman was gone, though Cindy was distraught for a week or two, until she got to know that waiter at the Mug & Muffin. Elbert didn't care about any of that. He was suddenly possessed of Latency Limiting Hormone by the gallon, rather than by the molecule. He was able to begin a sober, careful, cautious scientific examination of its properties and effects.

Goldman, on the other hand, bought a few animals at a pet shop. After whipping up a batch of Latency Limiting Hormone in his own lab at his house, he injected it into a rabbit, a cat, and a rat. When the animals (a) acted funny and then (b) didn't die, he gave a few junkie friends fifty bucks apiece and told them to try taking it in pill form.

The junkies loved it, freaked out in laughing fits, and Goldman was in business. From there on he only worked with dead drops and through third parties: That hurt his cut of the profits, but made him harder for the narcs to trace back. He named the stuff Flashback and handed out free samples and let them circulate, so as to get some rumors started, do a little market building. Then he started charging the middlemen five bucks a hit, and right off the bat he was selling 200 doses a week. In a month, he was doing ten times that business at twice the price, and his stuff was showing up as far away as D.C. and even Florida.

Goldman played LLH with a sort of bold caution. He knew that he was the sole source of the stuff, and that was both an advantage and a danger. No one could get the stuff from anyone else—unless someone decided to come kill him and steal the formula for themselves.

Failing that, some other underground chemist could figure out how to manufacture it, just as Goldman had. One thing was certain: The more popular Flashback became, the shorter-lived Goldman's monopoly on it would be. But while that monopoly held, he'd be making a mint.

He decided to go for the quick buck and flood the market. Money was always a great defense against whatever the other side might try. The more money he got quickly, the better he could protect himself.

The results on a few cats and rats might be a good enough measure of safety for the junkie at large, but Goldman used the whole drug-abusing public as his own personal guinea pigs. When several weeks had passed without any word coming back to him about bad side effects, he felt safe enough to treat himself to a dose of his own goods. He loaded up a pair of gelatin capsules with LLH and downed them with a glass of water.

And it was a blast. Suddenly all his worries about the narcs and the other pushers and how to stash his cash went away, and the whole world was reduced to *here* and *now*. He looked around the living room. Just dull books and records and the furniture. But maybe there was some good stuff someplace else in the house. The bedroom. Maybe there was something neat there. He rushed to the door and experienced a mad, wild moment of horrible frustration when the door jammed for a second. He kicked as hard as he could at it and the door bounced open.

Any toys? There was the video recorder. But there were only those dull old porno tapes. Goldman remembered how he usually really liked them a whole lot, but they didn't seem very interesting at the moment. There were some drawing things, pens and colored pencils that some ex-girlfriend had left here once. He could draw a picture of a fort. Instantly an image of the biggest, grandest fort in the whole world popped into his head, and he rushed to get it down on paper. He had barely gotten a start when he heard a barking noise

outside. It must be that really cute dog from next door. Maybe the dog would want to play. He ran outside.

He threw a stick for the dog for a while, until he saw some big birds fly overhead. Then he just had to see the swans down at the pond at the Public Gardens. He grabbed the subway into town, and found himself laughing with delight at the sight of the proud skyline as the train crossed the bridge across the Charles. All the people were so funny, and the ads on the subway were all really neat cartoons and funny pictures that he had never seen before.

He went from the Public Gardens to the Common to Chinatown to Washington Street and looked at all the stores. Everywhere he went it was as if it was the first time he had ever seen things, the first time he had ever tasted or smelled or felt things. He gorged on ice cream at Bailey's and got himself sick. He tried all the video games at a big arcade and got mad because his scores were so low—it was as if his coordination wasn't as good as it had been, as if he needed to relearn making fine movements. He bought a six pack of beer and drank it all in ten minutes and almost wet himself before he got to the men's room at MacDonalds. He rushed down to Quincy Market and looked at all the neat junk to buy, and bought some cookies and candy and then wandered around the North End giggling at all the funny men talking Italian and got himself lost . . .

And he knew the North End like the back of his hand. That was really dumb. Next time he would bring a map. He really shouldn't have wasted the whole day screwing around in the city. He had work to do. And it was cold—he had been wandering around Boston in March without a coat on.

The last of the Latency Limiting Hormone faded out of his bloodstream outside a hole-in-the-wall Italian restaurant, so he went in, ordered dinner, and tried to settle down a bit.

He was exhausted. It felt like he had burned up more energy in an afternoon than he usually did in a week. He knew he should try and eat something, but he felt

sick and bloated after all the cookies and candies and beer. He settled for a light salad and shook his head. That stuff was wild. Aside from too much candy, he felt fine. No side effects, it seemed. He'd definitely have to drop some again, soon.

Time to try some new names, he thought as he played with his salad. He could mix it up in Kool-Aid, call it Neo-Tonic. No one would get the joke, but why not? He giggled. Maybe there was still a little in his bloodstream.

The waiter was most polite to the rather wild-looking gentleman who came in and didn't order much. Uncharacteristically, it actually occurred to Goldman to leave a decent tip. He caught himself at it and smiled. If leaving a fair tip was a side effect, he could live with it. As he left, it suddenly struck him that he should have called Cindy, said something instead of just vanishing like that. It wasn't fair to treat her that way. Strange thoughts.

Sam Miller, Elbert's older brother, sat in his office and had a few strange thoughts of his own about Flashback. It looked like it was time for another bout with the slime who invented designer drugs. Most designer drugs had a chemical structure almost exactly like that of an illegal drug—heroin, for example. The human body couldn't tell the newly invented synthetic molecule from the naturally occurring—and illegal—substance, and so the junkies could get high on it.

Unfortunately, the law *could* tell the difference: One carbon atom hanging *this* way instead of *that*, and it wasn't heroin, it was a heroin-like substance not on the list of illegal drugs and controlled substances. You couldn't get busted for it, and the pushers and manufacturers were safe from the law. By the time the law had chugged through its paces and banned one designer drug, the basement chemists would have had time to develop three new witch's brews.

Almost as a by-product of this scam, the designers were learning how to produce synthetic versions of the

opiates and break their dependence on imports. Elbert would have been horrified to know it, but Goldman's previous experiments in producing synthetic heroin had been a lot of help in the effort to synthesize Latency Limiting Hormone.

Sam Miller didn't know a thing about LLH yet, but he knew plenty about Flashback. Reports were coming in from all over about the stuff. Not just reports on users, but on what the users were doing. Picking fights in public, for all the world like school bullies on the playground. Drinking poisons because they looked pretty, thinking pills were yummy candy. The stuff had some effect on coordination as well, and so there were a whole rash of stupid accidents. People walked into walls—and put cars through them. Had tantrums and screaming fits in public. Lost things—like all their clothes when it was still below freezing at night. Had weird firearms accidents, as though they were playing cops-and-robbers with live ammo. Committed remarkably dumb crimes, like trying to steal shiny new cars right off the showroom floor. As if irresponsible kids had gotten into adult bodies.

Stories about Flashback, also known as Neo-Tonic, were starting to get into the papers. People were spiking baby food with it and selling doses that way, calling it Gerber's Finest.

For a wonder and a blessing, this particular nasty drug seemed to have little or no effect on kids. No one under about 16 seemed to get any kick out of it. That was something.

Undercover agents had made buys, and so they had samples, and they had nailed its chemical structure. It seemed Flashback was a whole new departure, not just another heroin knock-off. The FDA was putting the rush on, and soon Flashback would be on the proscribed list where it belonged. Then they could make some busts—if they could find where it was coming from, which was a big if.

Sam's office had been handed the case because all the tracebacks had made it clear the goods came from the

Boston area. But the trail seemed to stop dead at the city limits. The core dealer was being very careful. No leads, no stool pigeons, no rumors.

Until, of course, his own brother came to dinner.

As she did from time to time, Sam's wife Louise decided that no college student had ever provided him or herself with enough protein to stay alive when left alone, so, just about the time Goldman was trying his fifth ride on Flashback, she invited Elbert to a real home-cooked dinner.

Elbert had always accepted these invitations with more good grace than actual enthusiasm, as his tastes ran to cheeseburgers and, when he was feeling avant-garde, spinakopita, while Louise leaned more in the direction of tofu and sprouts.

Even so, he came dutifully along that night and downed his bean curd without incident. Niece Emily seemed more interested in applying her food externally, and nephew George rather optimistically tried to sneak a bite or two to the kittens (who of course said no).

Afterwards, Louise put the kids to bed while Elbert and Sam did the dishes, and then everyone settled in the living room end of the living/dining room. Louise had herbal tea while the two brothers had good strong black coffee and the three of them talked over their work.

Or more accurately, Sam began to tell his wife and his brother about his problems with Flashback, and it never got any further than that. Sam hadn't gotten halfway through his recitation when Elbert started turning pale green.

"Oh, no," he said. "Sam, this Flashback stuff. Does it look like an opiate?"

"Real close relative."

"Jesus. Jesus, why is it I never read the papers!" Without another word, Elbert leapt up, and ran out the door. They saw him through the window rummaging in his car, and he was back inside in a moment. He tossed a thick three-ring binder to his brother. "I just finished

that and had it photocopied. Please tell me that's *not* your damn Flashback."

Sam opened the binder and flipped through the papers. Chemical diagrams. Precise descriptions of composition. Descriptions of limited tests on experimental animals.

Sam closed the binder and looked up. "This is it. Elbert, *you're* not pushing this stuff." It was a statement, not a question.

"No, no. Nothing that minor," Elbert said with an anxious note in his voice. "I just *discovered* it—and then got it stolen out from under my nose! I got it chemically isolated, and this was my paper on the subject. I was going to show it to you later. Wait a second," Elbert said suddenly. He had just made the connection. "You ever hear of a guy, Tim Goldman?"

Sam sat up very straight. "If you can get me to Goldman, we'll all be heroes. The man's leading the DEA's league of major bad-news creeps."

"Sam," Elbert said earnestly, "we *definitely* need to talk."

"Louise," Sam asked, "will we be shot if we went to my office where my files are?"

"Are the dishes done?"

"Spotless."

"Then you won't be shot," Louise said. "This sounds important."

"Except," Elbert said, "we should grab your files and then head over to my labs. There's some stuff I found out since I finished that paper last week—some very important stuff."

Goldman was wrapping up his Flashback trip just about the time the two brothers roared off in Elbert's '56 Mercury. Goldman shook his head. What a wild time! Great stuff. But the stuff was getting to be a drag to come down from. Every time it was a little worse—he always thought of something he should have done, someone he had been rotten to, some lie he had told or promise he had broken. He tried to tell himself that

this was just some weird paranoid side effect of LLH, but Tim had been through the come-down, the side effects of more drugs than most pharmacies stocked, and this didn't *feel* like a side effect. No matter how intense or bizarre or real-seeming a post-trip freakout felt, they had all felt as if, in some way, they were coming from the outside. They never felt this, this—*internal*. The sensation wasn't of a drug dancing on his nervous system, but of a part of his nervous system, his mind, waking up.

There was another thing. He had talked to some other users, and as great as it was for Goldman, the stuff didn't seem to affect Goldman as much as it did other people, and the people it really hit had much rougher come-downs after a while. Weirder still, some people it didn't touch at all, mostly the younger ones. No high at all. Well, at least *he* felt it some, and there was a solution to the weird come-down feeling and the relatively weak jolt LLH gave him. Goldman mixed up a double dose of his spiked Kool-Aid, and was taking off again on Neo-Tonic before he had finished landing.

"So what the hell isn't in this phone book of a paper?" Sam asked as they arrived at Elbert's Harvard lab. Sam had spent the ride over listening to Elbert explain LLH's action in excruciating detail, driving with the car's inside light on so Sam could peek at the charts and graphs inside the thick binder.

"For starters, a big, glaring, obvious, important point. I forgot all about how hormones work—brilliant, since I got into this line of work direct from messing with the thyroid gland."

"Yeah, go on."

"So show me you know," Elbert said. "How does the thyroid gland work?"

"It pumps out thyroid hormone, the stuff that controls the body's metabolism."

"There's more to it, remember?" Elbert said.

"Okay, yeah, the pituitary gland, right?" Sam had had a hard day before Elbert had even shown up, and

the evening had not been an easy one either. Now Elbert was determined to play twenty questions. It wasn't like Elbert to be this confident, this concerned about something. "The pituitary gland sits there watching how much thyroid is in the blood stream. The more thyroid hormone it sees, the more whachamacallit—"

"Thyroid-stimulating hormone. TSH."

"Yeah, right, TSH. So sue me, I don't remember everything from Biochem 101. The more thyroid the pituitary sees, the more TSH it shoots into the blood. And TSH makes the thyroid shut down. Anyway, if the body's metabolism is ticking over too fast, the surplus thyroid hormone isn't used and stays in the blood-stream. So the more thyroid in the blood, the more TSH gets pumped in, and the TSH tells the thyroid to stop producing its hormone. That cuts back the TSH, letting the thyroid gland go back into production. Everything stays in a nice steady state. A very solid feedback relationship."

"Right. Most of the hormone systems in the body work that way. One hormone or specialized chemical is used to regulate another."

"So?" Sam asked.

"So the existence of Latency Limiting Hormone implies the existence of a regulator hormone. I had to call it something, so I gave it a name—Mental Maturity Hormone. MMH. I haven't isolated it, but I've already found some evidence that MMH is really there. It *has* to be there."

"You sure are big on initials."

"Sam, skip the condescending big-brother guff. This is serious. I'm trying to get you to think through this thing, so you'll understand. Of course all this stuff is working on behavior, not on structure. It affects the way the brain works, the mind, but doesn't affect the brain itself. No physical change. And we've got to assume that MMH production won't be triggered until the body is good and ready for it, until the individual is ready to start learning adult behavior. But, suppose

that, outside of that, the LLH-MMH pair works like other hormone systems.

"Suppose it takes an unusually high level of LLH to stimulate MMH production in John Doe's body. He'll have enough LLH in his blood stream to enforce immature thinking, but not enough to stimulate MMH production. MMH, remember, would cause his mind to drop into a normal mature-thinking groove.

"If it all works the way I think it does, John Doe's body *will* produce MMH if he gets a series of big whopping doses of LLH to shock the glandular system into normal operation. A lot of LLH will jump-start his body into producing MMH, and bingo, one brand new adult mind."

Elbert paused for a moment and scratched his head. "Now lemme change the subject. Tell me something—describe the personality of the average adult drug abuser. The hard-core user, not the guy who dabbles with pot socially on weekends."

"Jesus, Elbert, come on. It can't be done."

"Yes, it can. Let me tell *you* some of the features of that personality: Disbelief in his or her own mortality. Certainty that flies in the face of everything—for example, knowing that he or she couldn't possibly become addicted to drugs, or that accidents and bad things only happen to other people. Irresponsibility. Selfishness. Impulsiveness. A basic unawareness that other people have rights—or even that other people are people. A strong ability to rationalize."

Sam looked up sharply at the anxious face, the worried look. This was not the little kid brother he had known. Maybe Elbert was finally noticing the real world. "Okay, I can think of exceptions," Sam said cautiously, "but I can pretty much live with that description." He had a nasty feeling he knew what Elbert was leading up to.

Elbert shrugged and went on. "I can make it shorter for you, in fact, one word: Immature. Drug addicts never really grow up. They're locked into immature thought patterns. Don't ask me why, but for some

reason my hypothetical Mental Maturity Hormone hasn't come into production. And when they take Latency Limiting Hormone, *what they're taking is a cure for immaturity*. Their stimulation threshold, the point where MMH finally kicks in, is too high. In any case, the LLH gland—wherever it is—never gets a feedback dose of MMH to signal it to shut down. Give these people artificial overdoses of Latency Limiting Hormone, and you'll finally force their glandular systems to pump out some Mental Maturity Hormone. Probably a lot of it. All at once."

Sam opened his mouth, shut it, opened it again. "Wait a minute. You're saying that there's a biochemical basis for mature, nonselfish, altruistic behavior. I don't like the sound of that."

"Neither do I," Elbert said grimly, "but I think it's true, no matter how we feel about it. And maybe I've stumbled across the drug that will eliminate a lot of drug abuse. The ones who have never grown up, never learned to be adults, or faced their own responsibilities and mortality, are going to do just that, very abruptly."

Goldman had fallen asleep under the influence of Flashback, and now he woke up screaming in the middle of the night. Faces were there in the dark, faces that had never been there before.

The kids. The schoolyard kids and teenagers who spent their milk money on his pills, his powders, his pot and speed and worse. The deadened minds, the wrecked lives. Learning to lie, learning to steal from stores, friends, family, to get what they suddenly needed, all in the name of lining Tim Goldman's pocket. *They were real*.

Real. That had never occurred to him before. Those faces that got thinner and sharper, the dull, sullen glint that replaced the sparkle of youth in their eyes, the surly, moody anger that overwhelmed the joy of life. Those were *people*, fragile kids, not robots programmed to spew up money for his comfort. Their ruined promise was his handiwork. Their families were wrecked so

he could buy a new Mercedes, a new tape deck. Family. He thought about his parents for the first time in years. Family. Who'd want *him* for a father? For the first time in his life, he realized how alone he had always felt.

Not just kids. He wrecked the lives of adults, too. Men, women, corporated executives and welfare cases. He had sucked them all dry, forced them to give their lives up to one pointless, destructive high or another.

Goldman staggered out of bed and started to make coffee. He had a lot of thinking to do.

The firemen got there in time to save Goldman's house, but the lab was a wreck. There were no injuries; no one was home. The cops were very much interested in the lab, and a DEA biochemist and his brother were also rather eager to poke through the wreck.

Elbert wasn't too surprised that four other clandestine drug factories burned the next night. Goldman was putting *everyone* out of business, not just himself. The cops were suddenly busy with some very promising leads phoned in by an anonymous tipster. And Elbert wasn't surprised at the huge cash donations, left in bundles of twenties and hundreds, that were found on the doorsteps of a half-dozen drug rehab centers around Boston and Cambridge. Goldman, it seemed, felt he had some dues to pay, and Elbert had the hunch Tim Goldman would be feeling the need to pay those back arrears to the human race for a long time to come. Oh, arson and bundles of money at night were pretty childish ways to go about it, but you couldn't expect him to develop a totally mature personality overnight. Elbert knew one more thing for certain: They wouldn't find Goldman, either. The guy was too smart for that.

Sam was a lot more spooked than Elbert at the rash of reformed drug abusers who suddenly started showing up at those same rehab centers, looking to get clean. A lot of people were suddenly eager to take responsibility for themselves, to go out and look for help.

LLH wasn't a panacea, an ideal solution, Elbert

thought. But at least it was a help, and had the virtue of backfiring on anyone who tried to abuse it.

Elbert realized that he had grown up a lot himself in the last few weeks. Had he accidentally ingested some LLH in the lab, enough to force his own gland system to pump out Mental Maturity Hormone? Or had it been natural, the pressures of work, and the hard thinking he had done? He had a hunch Sam was wondering the same thing. He hoped for the sake of his pride that the second answer was right, but it didn't matter. He had gotten off easy.

But there was one thing he hadn't told Sam yet, because he wasn't sure. Working from analogy with the other opiates, it seemed very likely that when MMH production cut in and shut down Latency Limiting Hormone production, the human went through some very rough withdrawal symptoms.

Poor Goldman. That would be hard on anyone, but Goldman's bloodstream had to be normally half-flooded with LLH, which meant he would have built up a high tolerance for the stuff. And when he finally managed to get enough Latency Limiting Hormone into his system to force the MMH system to work—that would mean the hell of stone-cold-turkey withdrawal.

Of course, if Elbert's theory was right, *everyone* went through that, without realizing what it was. Everyone experienced some of those special withdrawal symptoms, replete with their own unique mental anguish and total confusion of spirit. It was called "adolescence."

Elbert hoped he could get a grant to study the whole question.

**For Science Fiction with Science
In It, and Fantasy That Touches
The Heart of The Human Soul . . .**

Baen Books bring you Poul Anderson, Marion Zimmer Bradley, C.J. Cherryh, Gordon R. Dickson, David Drake, Robert L. Forward, Janet Morris, Jerry Pournelle, Fred Saberhagen, Michael Reaves, Jack Vance . . . all top names in science fiction and fantasy, plus new writers destined to reach the top of their fields. For a free catalog of all Baen Books, send three 22-cent stamps, plus your name and address, to

***Baen Books
260 Fifth Avenue, Suite 3S
New York, N.Y. 10001***

ROBERT A. HEINLEIN

"Heinlein knows more about blending provocative scientific thinking with strong human stories than any dozen other contemporary science fiction writers."

—*Chicago Sun-Times*

"Robert A. Heinlein wears imagination as though it were his private suit of clothes. What makes his work so rich is that he combines his lively, creative sense with an approach that is at once literate, informed, and exciting."

—*New York Times*

Seven of Robert A. Heinlein's best-loved titles are now available in superbly packaged new Baen editions, with embossed series-look covers by artist John Melo. Collect them all by sending in the order form below:

REVOLT IN 2100, 65589-2, \$3.50	<input type="checkbox"/>
METHUSELAH'S CHILDREN, 65597-3, \$3.50	<input type="checkbox"/>
THE GREEN HILLS OF EARTH, 65608-2, \$3.50	<input type="checkbox"/>
THE MAN WHO SOLD THE MOON, 65623-6, \$3.50	<input type="checkbox"/>
THE MENACE FROM EARTH*, 65636-8, \$3.50	<input type="checkbox"/>
ASSIGNMENT IN ETERNITY**, 65637-6, \$3.50	<input type="checkbox"/>
SIXTH COLUMN***, 65638-4, \$3.50	<input type="checkbox"/>

*To be published May 1987. **To be published July 1987. ***To be published October 1987. Any books ordered prior to publication date will be shipped at no extra charge as soon as they are available.

Please send me the books I have checked above. I enclose a check or money order for the combined cover price for the titles I have ordered, plus 75 cents for first-class postage and handling (for any number of titles) made out to Baen Books, Dept. B, 260 Fifth Avenue, New York, N.Y. 10001.

"Jerry Pournelle is one of a handful of writers who can speculate knowledgeably about future worlds. His space program background, readings in science, and Ph.D.'s in psychology and political science allow him to carefully work out the logical development of a world and its societies."—*Amazing*

JERRY POURNELLE

Experience the world-building talents of Jerry Pournelle, co-author (with Larry Niven) of the national bestsellers Footfall, The Mote in God's Eye, and Lucifer's Hammer! The following titles are available from Baen Books:

THE MERCENARY, 65594-9,

288 pp., \$2.95

KING DAVID'S SPACESHIP, 65616-3,

384 pp., \$3.50

HIGH JUSTICE, 65571-X, 288 pp., \$2.95

IMPERIAL STARS (ed.), 65603-1,

480 pp., \$3.95

Send the combined cover price plus 75 cents for first-class postage and handling to: Baen Books, Dept. B, 260 Fifth Avenue, New York, N.Y. 10001. We'll also send you our free catalog!

GORDON R. DICKSON

Winner of every award science fiction and fantasy to offer, Gordon Dickson is one of the major authors of this century. He creates heroes and enemies, not just characters in books; his stories celebrate bravery and virtue and the best in all of us. Collect some of the very best of Gordon Dickson's writing by ordering the books below.

FORWARD!, 55971-0, 256 pp., \$2.95	<input type="checkbox"/>
HOUR OF THE HORDE, 55905-2, 256 pp., \$2.95	<input type="checkbox"/>
INVADERS!, 55994-X, 256 pp., \$2.95	<input type="checkbox"/>
THE LAST DREAM, 65559-0, 288 pp., \$2.95	<input type="checkbox"/>
MINDSPAN, 65580-9, 288 pp., \$2.95	<input type="checkbox"/>
SURVIVAL!, 55927-3, 288 pp., \$2.75	<input type="checkbox"/>
WOLFLING, 55962-1, 256 pp., \$2.95	<input type="checkbox"/>
LIFESHIP (with Harry Harrison), 55981-8, 256 pp., \$2.95	<input type="checkbox"/>

Please send me the books I have checked above. I enclose a check or money order for the combined price plus 75 cents for first-class postage and handling made out to Baen Books, Dept. B, 260 Fifth Avenue, New York, N.Y. 10001.

WE'RE LOOKING FOR TROUBLE



Well, feedback, anyway. Baen Books endeavors to publish only the best in science fiction and fantasy—but we need you to tell us whether we're doing it right. Why not let us know? We'll award a Baen Books gift certificate worth \$100 (plus a copy of our catalog) to the reader who best tells us what he or she likes about Baen Books—and where we could do better. We reserve the right to quote any or all of you. Contest closes December 31, 1987. All letters should be addressed to Baen Books, 260 Fifth Avenue, New York, N.Y. 10001.



EDITED BY
JERRY POURNELLE AND JIM BAEN

FRONTIERS

Here is Volume VII of the world's only paperback magazine of science fiction and fact, the premier forum for exciting new fiction and penetrating speculative fact. In this volume:

**POUL ANDERSON
TIMOTHY ZAHN
CHARLES SHEFFIELD
G. HARRY STINE
ROGER MACBRIDE ALLEN
more!**



ISBN 0-671-65606-6

Printed in U.S.A.